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Experimental evaluation of an instructional unit on soil fertility and fertilizers

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EXPERIMENTAL EVALUATION OF AN INSTRUCTIONAL UNIT ON SOIL FERTILITY AND FERTILIZERS

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Experimental evaluation of an instructional unit on soil fertility and fertilizers

by

Hossein Hosseini

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INTRODUCTION

Instruction in vocational agriculture has become diversified within the past 20 years. The Vocational Education Act of 1963 (41) and the 1968 Vocational Education Amendments (42) provided for opportunities that would improve the quality and broaden the scope of vocational education programs. As a result, the vocational education curricula in public schools, most notably vocational agriculture programs, have undergone many changes. Most of these changes are centered on expanding vocational agriculture programs to help more students enter and successfully perform in agricultural occupations other than production agriculture. These changes also have increased the need for development and use of instructional materials which will help teachers in a variety of agricultural and agriculturally related subject matter areas.

Selection and use of instructional materials have always been a major responsibility of people involved in the vocational agriculture teaching profession. Although teaching aids play an important role in the teaching-learning process, it should be noted that their use alone will not make a good teacher. In 1971, Bruce (7, p. 61) suggested that:

> No amount of instructional materials will make a poor teacher of agriculture into a good teacher if his fundamental ideas about teaching are wrong.

A good vocational agriculture teacher, he emphasized, must base his teaching on sound educational philosophy and should reflect good teaching methods. Instructional materials should be recognized as aids which help the student better understand what is being taught.

During the early years of vocational education, many teachers were responsible for preparing their own instructional materials. The first attempt to help teachers in this task was reported to have been made by the Federal Board for Vocational Education (20). This Board attempted to help provide teachers with high quality reference materials, organized in a manner conducive to effective use in teaching-learning situations. The Board, however, found it impossible to produce all the materials needed. As a result, until recent years teachers were still involved in preparing many of their own instructional materials.

Changes in the vocational agriculture program created a need for more student-centered instructional materials. As these programs broadened in scope, teachers had to decide on what to teach, how to teach it, and to whom it should be taught. This situation required that vocational agriculture teachers cover a wide variety of subject matter areas in order to meet the needs of the students they taught. Having teachers prepare their own instructional materials was no longer effective or practical as the vast majority of them had little or no training in developing such materials. In addition, because of the diversity of program content, many teachers simply did not have time or adequate background in the various subject matter areas of their programs to develop effective instructional materials in the subjects they taught.

In order to meet the continuing demand for instructional materials, many state educational agencies have been involved in developing instructional materials for use by vocational agriculture teachers. The degree of involvement of these agencies in producing instructional materials varies among states. States, such as Ohio, Texas, and Oklahoma, for example, have established agricultural curriculum material centers or laboratories, while other state agencies have used summer workshops as a means of developing instructional materials. Other organizations have also been involved in developing instructional materials for vocational agriculture teachers. Commercial firms, for example, have played a significant role in preparing and marketing instructional materials used by vocational agriculture teachers.

Because of the efforts of these groups, teachers of vocational agriculture no longer are confronted with the problem of developing their own instructional materials. Today they are faced with a new problem of not being able to make appropriate selections from the increasing supply available to them through a variety of sources.

A major concern among some educators has been that materials have been used without first determining their effectiveness in increasing knowledge and bringing about desired behavioral changes in the learner. Bruce (7, p. 61), for example, noted:

> If instructional materials are to be of maximum value to teachers of agriculture, it is essential that they be evaluated in terms of the student and the purpose for which they are intended.

Ridenour described the need for evaluating instructional materials as follows (34, p. 137):

> The effectiveness of educational materials in the teaching-learning process will be unknown until the materials have been tried in the classroom and evaluated in terms of whether or not they have brought about the behavior changes in students that were specified in the educational objectives. The work of a curriculum material service

> should be directed by both formal and informal evaluative procedures which indicates the kinds of materials which are most effective. Such evaluation procedure should provide firm direction for the preparation of materials.

Urbanic (43) was also concerned about the fact that very few materials which have been developed in different universities, curriculum materials centers, and by other organizations have been tested for their effectiveness.

Gliem (15) recommended that studies be conducted to evaluate the effectiveness of using instructional materials in bringing about changes in knowledge, attitude, and abilities of students. Briers (6), after evaluating the effectiveness of an instructional packet in SOE, recommended that instructional materials in other areas of agriculture be tested before dissemination to teachers. Kotrlik (24) conducted a study to evaluate the suitability of available instructional materials in Texas vocational agriculture programs. Afterwards, he recommended that similar studies be conducted in other states.

Educators agree that development, distribution, and use of instructional materials alone is not adequate. They recommend that instructional materials need to be evaluated through carefully designed experiments to determine their educational value. Evaluations should be conducted to determine if instructional materials are effective before they are distributed among vocational agriculture teachers.

A recent project entitled "Strategies for Revision of Curriculum and Program Restructuring of Vocational Agriculture in Iowa" was initiated at Iowa State University to address the problem of providing Iowa vocational agriculture teachers with meaningful teaching materials. This project had, among its objectives, to develop curriculum materials that would assist vocational agriculture teachers in restructuring their programs to the semester approach to class organization. An outcome of the project was the development of 24 units of instruction on technical agriculture topics.

Based upon the above recommendations, a strategy for assessing the effectiveness of these units was developed by project staff and implemented as a part of project activities. This investigation is one facet of the overall project evaluation facets.

The purpose of this study was to evaluate the effectiveness of an instructional unit on soil fertility and fertilizers which was developed for use by vocational agriculture teachers in Iowa. More specifically, this study was conducted to:

(1) Determine if the use of this unit would significantly increase students' knowledge of soil fertility and fertilizers.

(2) Determine effects of using this unit on student achievement as compared with instructional materials traditionally used by vocational agriculture teachers.

(3) Identify changes in student attitudes as a result of using these materials.

(4) Determine if significant relationships exist among students' personal or situational characteristics, and student performance on soil fertility knowledge inventory or soil

fertility attitude inventory.

(5) Identify teachers' opinions on such items as scope of unit, accuracy of information, format of materials, etc.

REVIEW OF LITERATURE

The literature was classified in two categories. First, literature related to the need for evaluation of instructional materials was examined to draw a rationale and theoretical framework for the study. Second, studies related to instructional material evaluation in vocational agriculture were reviewed.

Literature Related to the Need for Evaluation of Instructional Materials

Many educators have noted that considerable effort and expense had been committed to development and distribution of instructional materials by different public and private agencies. They maintained that teachers of vocational agriculture had been faced with the problem of selecting among a variety of instructional materials available on the market. This selection procedure, as Briers noted in 1978, involved consideration by teachers of such questions as (6, p. 29):

1. Does the instructional material "cover the subject matter I wish to teach"?
2. Is difficulty level about "right"?
3. Are the materials economical?
4. Should the materials be used as a teacher reference, a student reference, a textbook, etc.?

The main concern of the teacher, he noted, was to know whether or not the instructional materials would help accomplish the objectives for which the teacher was striving to achieve. Tyler (40) emphasized that learning experiences should be selected on the basis of how well they help attain planned objectives. He described the goal of evaluating learning experiences as follows (40, p. 105):

> It should be clear that evaluation then becomes a process for finding out how far the learning experiences as developed and organized are actually producing the desired results and the process of evaluation will involve identifying the strengths and weaknesses of the plans. . . . As a result of evaluation, it is possible to note in what respects the curriculum is effective and in what respects it needs improvement.

Many educators in agricultural education have voiced their concerns about the effectiveness of instructional materials. In 1971, Bruce (7) noted that if instructional materials were to be of maximum value to teachers of agriculture, they should be evaluated in terms of student achievement and the purpose for which they were designed.

Ridenour (34) conducted a study during 1965 to identify guidelines for a state vocational agriculture curriculum materials service. He reported that only 22 percent of the states surveyed had evaluated the effectiveness of their curriculum materials. Based on his findings, he suggested the following guideline for evaluation of curriculum materials services (34, p. 11):

> A curriculum materials service should develop evaluative procedures that can be used for determining the effectiveness of the various educational media disseminated through the service.

Geesey described the need for evaluation of instructional materials as follows (14, p. 17):

> Considerable effort and expense goes into the development and production of instructional materials but their impact on the effectiveness of instruction is often neglected.

> Testing of instructional materials should be pursued to determine learning specific to the instructional materials used with a specific unit of a curriculum.

Available materials, he noted, had been developed and in some cases revised mainly from suggestions gleaned from supervisors, teachers, and professional employees in the field. This, he maintained, was not enough. He suggested that it was more important to measure their effectiveness before the materials were used in the classroom.

Gliem, another agricultural educator, explained the need for evaluation of instructional materials as follows (15, p. 5):

> With the increased amount of instructional materials available, one has seen an influx of such materials into the educational market. Many people are using these instructional materials, but few have been evaluated as to their effectiveness in teaching students, in increasing cognitive knowledge and in bringing about the desired behavioral changes in students as determined by teachers using the material.

Educators have also pointed out the need for evaluating the educational values of the materials before they are marketed. Kowalka (25), for example, suggested that instructional materials be tested and revised before they are distributed among teachers.

In summary, the review of literature revealed that instructional materials should be evaluated before they are disseminated. Carefully designed evaluation studies are needed to determine the effectiveness of instructional materials in increasing student knowledge and skill and bringing about behavioral changes desired by teachers.

Review of Related Research on Instructional Materials Evaluation

An overriding concern among some educators has been that of evaluating instructional materials. In recent years, several studies were conducted to identify the effectiveness of different types of instructional materials. These studies were categorized as follows:

1. Media studies through which the effectiveness of using different media in teaching were investigated.
2. Experimental studies which were designed to investigate the effectiveness of various instructional materials.

Several studies in each category were reviewed. More emphasis, however, was placed on the second category because of the experimental nature of this author's investigation.

During 1970, Kahler (22) conducted an experimental study to evaluate the effectiveness of selected techniques and resources on instruction in vocational agriculture. The techniques which were examined consisted of the following: audio-tutorial, single concept film, prepared lesson plan, field trip, demonstration, videotape, and overhead projected transparency. The study was conducted in 48 Iowa high schools. A pretest-posttest control group design was used. His findings revealed no significant difference among these techniques, but he was able to show that some techniques were more effective in certain areas than others. For example, when used to teach a commercial fertilizer unit, audio-tutorial and field trip were more effective than other techniques. Based on his findings, Kahler supported a multimedia approach in teaching vocational agriculture. He concluded (22, p. 31):

> While this study evaluated the use of a single technique in each of treatment groups, in a normal instructional situation a combination of these techniques would be used to present the subject matter. Observations made from the analysis of the data in this study support a multi-media approach in presenting the subject matter.

In another media study conducted by Miller (28), the goal was to compare different methods of teaching rafter construction. Teaching methods used in his study were: lecture-discussion, individualized instruction, slides, skill sheets, and the use of skill sheets along with slides. His sample consisted of 125 students in an agricultural mechanization class at Iowa State University. He was unable to prove any statistically significant different in student achievement level between treatment groups.

During 1976, Warfel (44) compared lecture-filmstrip and lecture-demonstration techniques in teaching parliamentary procedure to 225 individuals who attended an FFA orientation camp in Indiana. He used a pretest-posttest control group design. His findings indicated that there was no significant difference between the achievement score of two groups as measured by the parliamentary procedure test instrument.

The concept of individualized student instruction was the subject of many agricultural education studies reviewed. Most of these studies were similar in nature to those reported by Oen and Kowalka during 1970 and 1974, respectively. Oen (30) developed an individualized learning manual on turfgrass and service. Three groups were included in his experiment. The first group used the individualized instruction method, the second group used lecture-discussion method, and the last group was considered control with no instruction. He found that students who were taught under individualized instruction method scored significantly higher than those who had been instructed under the lecture-discussion method in two of the six subject areas included in the study. Kowalka's study was also related to the effectiveness of an individualized instructional manual. The manual was written on electricity and electrical wiring. He used Solomon four-group design to control for testing and interaction of testing and treatment. He reported his findings as follows (25, p. 5):

> A significant difference was found between posttest scores of the treatment and control groups, favoring the treatment group. The differences within the treatment and control groups were analyzed by using pretest and posttest scores, resulting in a finding of no significant differences within either group.

A more recent study was completed by McCully (26) in 1981. The purpose of this study was to compare independent study to group study methods in Mississippi vocational agriculture programs. Nine schools with a total of 175 students completed the independent study treatment, and seven schools with a total of 157 students completed the lecture-discussion treatment. Seven schools with 123 students served as control. The pretest-posttest control group design was used. McCully reported that there was no significant difference between the independent study and the lecture-discussion methods. Furthermore, no significant difference was found between student's and teacher's opinion toward instructional methods used in testing the approaches.

Results of media studies reviewed indicated that although some techniques were more effective than others in teaching specific subject matter, the differences were not significant. Furthermore, results of these studies supported the idea of a multimedia approach to teaching vocational agriculture.

Other studies have focused on teacher's perception of instructional materials. Tillman (37) conducted a study to determine the extent that Virginia vocational agriculture teachers were using instructional materials developed by the Agricultural Education Program Area at Virginia Polytechnic Institute and State University. In addition, he was interested in identifying the "special features" that teachers wanted in new instructional materials. A questionnaire with the list of 17 materials which had been developed and disseminated was used to collect teacher's responses. He reported that vocational agriculture teachers rated all 17 instructional materials as "good". He also found that teachers wanted transparency masters, student workbooks, tear-out pages, and teachers' keys included in the materials.

In a similar study, Roediger (35) described teacher's rating of instructional materials for three vocational agriculture program areas in Ohio. These materials were developed and distributed by Ohio Agricultural Education Curriculum Materials Service. He found that teachers favored the scope of the subject matter content, level of writing, ratio of "why" information to "how" information, use of student activities, and use of student objectives. He also found that teachers in his study wanted more transparencies in the manuals.

In a study completed during 1978, Kotrlik (24) attempted to determine the suitability of state adopted textbooks and single topic student materials for group instructional purposes as rated by Texas vocational agriculture teachers. He used a rather extensive questionnaire to collect data from a sample of 400 Texas vocational agriculture teachers. He summarized his findings as follows (24, p. v.):

> While teachers believed that both state adopted textbooks and single topic student materials were appropriate for use in their instructional programs and both types of materials should continue to be used, the attitude of teachers was more positive toward single topic student materials and a significant majority of them preferred single topic student materials over state adopted textbooks. . . . Teachers did not perceive that state adopted textbooks were as up-to-date and technically accurate as were single topic student materials.

Readability of vocational horticulture instructional materials was the title of a study reported by Welch (46) in 1981. In this study, Welch sent a questionnaire to one horticulture teacher at each of the 40 schools participating in the 1981 Ohio Horticulture Achievement Testing Program. He used the Dale-Chall Readability Formula to predict the readability of materials listed in his questionnaire.

Welch found that teachers were using a wide variety of printed materials. Whereas the majority of the materials were written at an appropriate grade level, student scores on statewide tests led to the assumption that students were actually reading at a level below grade level placement. Welch, therefore, concluded that most of the materials were too difficult in terms of reading level for the majority of students using them.

Several experimental studies on vocational agriculture instructional materials have been conducted during recent years. The purpose of this part of the review of literature was to examine and summarize the findings of these studies.

A relatively early experimental study on instructional materials in vocational agriculture was completed and reported by Ehresman (12) in 1966. The objective of his experiment was to evaluate the effectiveness of structured, printed instructional materials on agricultural cooperatives. His experimental group consisted of 10 Illinois schools in which structured materials were used for teaching cooperatives. Ten schools served as a "control" group in which unstructured, printed instructional materials were used. A pretest-posttest control group design was used. In order to identify the effectiveness of his experimental variable, Ehresman compared student knowledge of cooperatives in the experimental group as measured by a criterion-reference test with that of the control group.

He reported no significant difference in the mean posttest scores of students. He found, however, favorable reaction from teachers using the structured instructional materials. Ehresman (12) concluded that structured source units may be a valuable aid because they would help teachers save time in planning and preparation.

Barker (3) conducted an experimental study during 1967 to measure the effectiveness of instructional units and approaches to teaching and learning. His units were designed to enhance student understanding of profit-maximizing principles as applied to farm business management.

Twenty-two schools in Ohio were assigned to three different treatment levels. Six high schools served as control schools. Seven schools served as a "pilot block" to teach from the units in an uninterrupted sequence. Teachers in nine high schools integrated the instructional units with other subject matters. A posttest (45 multiple choice questions) was used to measure student understanding of the contents of the units. He found that the group using only the instructional units obtained the highest score on the posttest, followed by the nine schools using the integrated approach. The control group had the lowest posttest scores. Each of the group mean differences were statistically significant. Analysis of data allowed Barker to conclude (3, p. 125):

> that the developed instructional units did enhance understanding . . . beyond the traditional manner of teaching farm management to students of vocational agriculture.

A study reported by Urbanic (43) was designed to evaluate the effectiveness of a student reference in teaching ornamental horticulture. This study was somewhat unique as the researcher not only evaluated the unit in terms of its effect on student knowledge, but also he tried to measure student attitude towards the reference unit. The design used for this study was the posttest-only control group design with eight schools in both the experimental and control treatment groups. An attitude scale was used to measure student and teacher attitudes toward student references, objectives, exercises, writing style, subject matter content, and pictures and illustrations in the unit.

Results of this study indicated no significant difference in knowledge test scores between groups. Furthermore, no significant difference was found in attitudes between treatment groups. Urbanic (43) concluded, however, that teachers of vocational horticulture were more favorable toward the use of student references than were their students.

Using two groups in a pretest-posttest control group design, Wilson (47) evaluated the effectiveness of different teaching materials on vocational agriculture student achievement in electricity. Nineteen teachers in the experimental group used a source unit to teach electricity. The control group, which consisted of 18 teachers, received only a teaching outline. The results revealed that the mean test scores of students in the experimental group were significantly higher than those for the control group.

Another experimental study on instructional materials evaluation was completed by Zurbrick (48). In his study, Zurbrick evaluated the effectiveness of a teacher reference, which was developed to enhance student understanding of basic agricultural marketing principles. The design for this study was a pretest-posttest control group design. A total of 16 teachers in the western half of the state of Ohio participated in the study. Teachers in the experimental group were supplied with the source unit, whereas the teachers in the control group only received student objectives and used their own references in teaching marketing principles. Student achievement was measured through the use of a 50-item multiple choice test.

Zurbrick (48) used analysis of covariance with the pretest being the only covariate to determine the effectiveness of the teacher reference on student achievement. He concluded that (48, p. 115):

> The teacher reference on marketing principles enhances student understanding of marketing principles to a significant degree when compared to the traditional

> techniques of teaching marketing principles employed by teachers in the control group.

Furthermore, he found that teachers who used the teacher reference spend less time preparing for instruction and more time in teaching marketing principles.

Rather than using two experimental groups, as was the case in some previous research, Gliem (15) used three levels of the independent variable. The purpose of his study was to evaluate the effectiveness of a student reference in teaching ladder safety in agricultural mechanics to high school students enrolled in vocational agriculture. The independent variable which was manipulated in the study was the extent to which teachers and students had access to the student reference. Three groups were included in his study. In the first group, both teachers and students received the student reference. In the second group, only teachers received the reference, and in the third group, neither the teachers nor the students received the student reference. A posttest-only control group design with intact classes serving as the experimental units was used. A total of 30 schools (10 in each group) participated in the study. The results of his study indicated that students in all groups performed about the same on a cognitive posttest on ladder safety. He concluded that the student reference on ladder safety was not any more effective than the other techniques that were available to teachers and students to teach ladder safety.

A similar study was completed by Geesey (14) in 1976. Geesey's objective was to identify the effectiveness of the type of instructional materials used in teaching tree identification on the achievement of

Ohio high school vocational agriculture students. The three treatment levels used in his study were: (1) a teacher's guide in combination with a student manual, (2) a student manual only, and (3) references and instructional materials normally used by the teacher in teaching tree identification (control). Student achievement was measured by the score on a criterion-referenced test on tree identification. Geesey employed a modified Solomon four-group design. Intact classes of 21 vocational agriculture teachers in Ohio were randomly assigned to one of the three levels of the treatment.

Conclusions drawn by Geesey were as follows (14, p. 103):

> The use of the student manual and the teacher's guide made no significant difference in student achievement as measured by posttest scores when compared to students taught tree identification without the use of the student manual and teacher's guide.

The results of his study, however, indicated that student achievement as measured by posttest scores, was positively related to the extent of student use of instructional materials and the extent of student interest generated by their use.

Howel (19) conducted a study to determine if the use of a student manual in environmental protection aided high school students enrolled in vocational agriculture and science classes in formulating positive attitudes toward the protection of the environment. He used a Solomon four-group design in his study. He developed and used an attitude inventory to measure student's attitude toward the protection of the environment. His findings indicated that there was no statistically significant difference in posttest attitude inventory scores between students using the manual and students not using the manual. He also found that science classes had a higher posttest attitude score than did the vocational agriculture classes.

Student achievement in technical agriculture subject matter was not the only area investigated by researchers in agricultural education. In a study completed during 1965, Sullivan (36) developed and tested a teacher guide for improvement of reading achievement of vocational agriculture students in Maryland. She assigned 12 tenth-grade vocational agriculture classes to two groups: experimental and control. The design used in her study was a pretest-posttest control group design.

Sullivan found that there was no conclusive evidence that the guide was effective in enabling agriculture teachers to help students make significant gains in reading achievement. She also found positive and significant relationships of intelligence and achievement in reading. Teachers in her study considered the guide as a valuable tool in incorporating reading improvement procedures into the vocational agriculture programs.

Reimold (33) took a somewhat different approach. He developed and tested a nematode unit in high school biology and vocational agriculture classes. His finding indicated that boys in biology classes scored higher than boys in vocational agriculture. The difference, however, was not significant. He also found that there was a significant positive correlation between students' posttest scores and their I.Q., class rank, and pretest scores.

An instructional packet on supervised occupational experience programs (SOE) for beginning vocational agriculture students in Iowa was evaluated by Briers (6). Briers used a pretest-posttest control group design. Forty teachers were randomly assigned to the experimental and control treatments. Students in his study were asked to complete the following: (1) an SOE knowledge inventory, (2) an SOE attitude inventory, and (3) an SOE planning inventory. Usable data were gathered from 17 of the experimental treatment classes and 16 classes of the control treatment group.

Briers (6) found that experimental group classes scored significantly higher than the control group on the SOE knowledge inventory. Furthermore, he found that the experimental treatment group performed significantly better than the control treatment group on the SOE program planning inventory.

Jones (21) completed a follow-up study on the SOE packet developed by Briers. Jones evaluated the impact of the packet developed by Briers in terms of student agricultural knowledge achievement. The study was a posttest-only control group design with 16 schools randomly assigned to the experimental treatment and 16 schools assigned to the control treatment.

Results of Jones' study indicated that students in the experimental treatment group had significantly higher achievement in plant and soil science than those in the control group. No significant difference was reported in achievement scores between the experimental and control groups in the areas of animal science and agricultural mechanics. Furthermore, knowledge of SOE possessed by Iowa vocational agriculture freshman students was found to be a reliable predictor of students' high school achievement in animal science, plant and soil science, and agricultural mechanics.

Another Iowa study, completed by Townsend (38) during 1981, was conducted to evaluate the effectiveness of an instructional packet on leadership and FFA. Using a posttest-only control group design, Townsend placed 17 schools in group 1 (packet and inservice); 19 schools in group 2 (packet only); and 18 schools in group 3 (control). Two instruments were used to collect student knowledge of FFA and students' attitude toward FFA.

Townsend reported that (38, p. 71):

> There was no significant difference in FFA knowledge scores among groups. However, the mean scores for the two experimental groups were higher than those for the control group. . . . Students in schools whose teachers were in group 1 (packet and inservice) had significantly higher attitude scores on the FFA attitude scale than the students included in the control treatment group.

Summary of the Review of Literature

The review of literature indicates that educators have been and continue to be concerned about evaluation of instructional materials used by vocational agriculture teachers. They emphasized the need for evaluation of instructional materials before such materials are disseminated among teachers and students.

Experimental studies which evaluated instructional materials gave different results. While some of the experiments on the incorporation and effective use of instructional materials have shown positive results on student achievement, other experiments have indicated little effect on student achievement. Collectively, studies reviewed indicated that properly constructed materials and carefully designed experiments tended to result in detectable differences in achievement.

Researchers have used a variety of procedures in their experiments. The pretest-posttest control group design and posttest-only control group design were more frequently used than others. The effectiveness of instructional materials was usually measured by criterion-referenced achievement tests developed by the investigators. In some cases, attitude inventories were developed and used by the investigator to measure students/teachers attitudes toward the materials being tested.

Several researchers used teacher inservice as an experimental treatment. Although this helped teachers in becoming more familiar with materials, it was not found to significantly increase student achievement in the experiment. Finally, researchers suggested that instructional materials be revised and updated based on the findings of evaluation studies.

METHODS AND PROCEDURES

The primary purpose of this study was to evaluate the effectiveness of an instructional unit on soil fertility and fertilizers which was developed to be used by vocational agriculture teachers in Iowa. In this chapter, research methods and procedures utilized in accomplishing the purpose of this study are reported under the following titles: (1) Definition of Terms, (2) Development of Instructional Unit, (3) Design, (4) Selection of Sample, (5) Instrumentation, (6) Collection of Data, and (7) Analysis of Data.

Definition of Terms

The following terms were defined to provide a common basis for understanding of this study:

Student knowledge: Student understanding of soil fertility and fertilizer concepts as measured by a criterion-referenced test.

Student attitude: Student self-reported feelings' toward selected concepts in soil fertility and fertilizers reflected on an attitude inventory instrument.

Project Staff: Staff members in the Agricultural Education Department at Iowa State University who worked on Project 2000, a shortened name for a research project entitled "Strategies for Revision of Curriculum and Program Restructuring of Vocational Agriculture in Iowa".

Instructional unit: A publication composed of printed materials outlining problem areas, study questions, learning activities, etc. designed to help vocational agriculture teachers organize teaching-learning process in the area of soil fertility and fertilizers.

Intact class: A class composed of all students normally enrolled in a soil fertility and fertilizers course that was selected for this study. That is, all students in the class were included in the study because their teachers was selected to participate in the evaluation of the instructional unit.

Treatment unit: Vocational agriculture teachers and their class who participated in the experiment.

School: Iowa high schools in which the experiment was conducted. The term may also be used when reference is made to the vocational agriculture programs.

Development of Instructional Unit

The instructional unit was developed by the investigator as part of a research project entitled "Strategies for Revision of Curriculum and Program Restructuring of Vocational Agriculture in Iowa". The format of the unit was organized around a problem solving approach to the teaching-learning process. Earlier in the project, problem solving orientation was identified as being one of the basic principles for agriculture and agribusiness education in Iowa. This principle was defined as follows (11, p. 6):

> Effective problem solving involves a genuine problem in which alternate courses of action are possible. . . . Problem solving, as a learning technique, is fully effective only when the problem is genuine rather than manufactured, the problem is accepted by the student as a problem of his own, and the student participates with others in planning and directing the process by which the solution is reached. As a method of learning problem solving obviously differs in certain respects from memorizing or even understanding the accumulated bodies of knowledge per se. These bodies of knowledge are, of course, of enormous importance in problem-solving process, but they are used as resources in the solution of the problem rather than the direct study of the particular body of knowledge itself.

Results of a study completed by Archer (2) in 1976, indicated that educators, parents, and students perceived problem solving as being an important basic principle in the agriculture and agribusiness education in Iowa. Archer's study supported the need for emphasizing this approach in the instructional materials development process.

Based on this principle, nine problems in the area of soil fertility and fertilizers were identified and included in the instructional unit. The problems were as follows:

1. What is the role of essential nutrients to plant growth?
2. What are some concepts of soil fertility and productivity?
3. Why should acid soils be limed?
4. How are nutrient needs determined?
5. How do I interpret the soil test results?
6. What are the different sources of nutrients?
7. How should fertilizers be selected?
8. How should fertilizers be applied?
9. How should fertilizer materials be handled safely?

Each of the nine problem areas in the unit included a statement of the problem, a suggested situational statement, study questions, references and instructional materials, learner needs, a suggested interest approach, learning activities, conclusion, evaluation criteria, and optional learning activities.

Each problem was stated in a manner that required or encouraged the learner to make a decision. It was stated in a question form to make it more relevant for the learner. The teacher was asked to help students identify a situation preferably in the local community for which the problem may be relevant. The idea was to make the problem as real to the agricultural world as possible. Each problem was then broken into several study questions which could be dealt with by students or teacher. Study questions were designed so as to suggest instructional approaches for the teacher to use in assisting students to arrive at the proper decision about the problem.

All external references (books, publications, films, etc.) which were not included in the instructional unit were listed to help teachers secure necessary information and materials for learning activities. Where applicable, these materials were keyed to the learning activities in which they were suggested to be used.

The format also included learner needs, which were identified by the project staff in the earlier phases of the project. Those needs that the author felt should be emphasized through the learning activities were listed. Each need stated was keyed to a specific learning activity in the instructional unit. In this manner, psychological, sociological, and educational needs of students were emphasized in the learning activities.

Interest approach, as the name implies, was simply a short activity suggested for the purpose of arousing student interest in studying the problem. An additional intent of the interest approach was to make clear the relevance of the problem to the learner.

A variety of group and individualized learning activities was suggested for each problem area. This was the most important part of the instructional unit as it included those learning experiences which were designed to enhance learning among students. These learning activities were directly related to the study questions, which were listed in the beginning of each problem area.

In the conclusion section, answers to the problem, and study questions were stated. Where possible, an activity was suggested with the goal of having students draw their own conclusions about the problem, making sure that their conclusions were the right ones. Furthermore, in the conclusion section, major concepts discussed in the learning activities were pulled together.

The purpose of listing evaluation criteria was to describe what the student should have accomplished as a result of instruction in each problem area. It was intended that the evaluation criteria listed would help the teacher identify possible techniques that could be employed to measure student achievement in each problem area.

Finally, those activities that were not fully developed (i.e., no activity sheets in the unit) but were applicable to the local situations were listed as optional learning activities. Additional space was provided for the teacher to include his or her own activities.

For each problem area in the unit, a number of transparencies, student activity sheets, and information sheets were provided. Suggestions were made for their use in the learning activities section. A special coding system was used to insure proper placement of these materials in the unit in case they were removed by the teacher. A list of all instructional materials and references used throughout the unit was provided in the front section of the unit. A vocabulary list was included to help teachers emphasize the spelling and meaning of those terms which were unique to the area of soil fertility and fertilizers.

A student text entitled <u>Field Crop Nutrition</u> was recommended to be used with the instructional unit. This student text had been developed by the Ohio Agricultural Education Curriculum Material Service. Criteria used in the selection of this student text included cost, availability, relevance to the problem areas identified in the unit, reading level, and accuracy of information presented.

Design

The design used for this investigation was a pretest-posttest control group design, described in Tuckman (39). The design could be graphically represented as:

$$R \quad O_1O_2 \quad X_1 \quad O_3O_4O_5O_6$$

$$R \quad O_7O_8 \quad X_2 \quad O_9O_{10}O_{11}O_{12}O_{13}$$

The symbols are explained as follows:

R — indicates random assignment to the separate treatment groups (experimental and control).

X_1 — represents the treatment group in which vocational agriculture teachers taught soil fertility and fertilizers to their students using "conventional" materials and methods (the control treatment).

X_2 — represents the treatment group in which vocational agriculture teachers taught soil fertility and fertilizers using the instructional unit developed by the investigator (the experimental treatment).

O_1O_2, O_7O_8 — represent a pretest designed to measure student knowledge of soil fertility and fertilizers, and a pretest designed to measure student attitudes toward some concepts in soil fertility and fertilizers.

O_3O_4, O_9O_{10} — represent a posttest designed to measure student knowledge of soil fertility and fertilizers, and a posttest designed to measure student attitudes toward some concepts in soil fertility and fertilizers.

O_5, O_{11} — represent a questionnaire designed to collect personal and situational information from students in the control group, and the experimental group.

O_6, O_{12} — represent a questionnaire designed to collect personal, situational, and procedural data from vocational agriculture teachers in the control group, and the experimental group.

O_{13} — represents an evaluation instrument designed to be used by vocational agriculture teachers in the experimental treatment group to report their opinion about the instructional unit.

The proper use of this design as explained by Tuckman (39) was to help in controlling all the simple sources of invalidity. Since a control group is used, which would presumably have all the same experiences as the experimental group other than the experience of the treatment itself, this design controls for history, maturation, and regression.

Furthermore, by randomly assigning subjects to experimental and control conditions, both selection and mortality, which are threats to validity, were controlled.

Selection of Sample

A list of all vocational agriculture teachers in Iowa during 1981-1982 school year was obtained. Identification of teachers to be included in the study was accomplished by asking project staff to nominate those teachers whom they felt would be able to provide an adequate test of instructional unit. Seventy-two teachers were nominated as potential participants in the experiment. A list of these teachers was then reviewed and verified by the faculty members of the Agricultural Education Department at Iowa State University. Of these seventy-two teachers, half were randomly assigned to the experimental treatment and the other half was assigned to the control treatment.

Letters (see Appendix A) were then sent to the potential teachers in both experimental and control treatment groups, explaining briefly the project and soliciting their willingness to participate in the study. A self-stamped postcard was included for the teachers to indicate their willingness to participate, and to report the number of students in their soil fertility class. They were also asked to secure the permission of building principals in their school to participate in the study.

Participation on the part of teachers in the experimental group required that they:

1. Teach a unit in soil fertility and fertilizers during the period from November 1, 1981, to February 1, 1982.
2. Administer pretest and posttest instruments to their students.
3. Use the instructional unit developed by the investigator to teach soil fertility and fertilizers to their students.

Teachers in the control treatment group were asked to meet the first two criteria. Twenty-one teachers in the experimental group and 19 teachers in the control group indicated their willingness to participate. To insure equal sample size, 19 teachers in each group were considered as participants.

Although assignment of teachers to the treatment levels was done at random, as noted, their selection was not accomplished at random. Therefore, inferences based on the results of this study were made only to the individuals included in the experiment. Such inferences were not and should not be extended to all vocational agriculture teachers in Iowa on a statistical basis.

One question which is often raised by educational researchers is related to the sample size. In the beginning of this experiment, the investigator was interested in determining whether a sufficient number of teachers was selected in the experiment. It was observed through the review of literature that small size samples may lead to relatively high sampling errors and insignificant results (5). Attempts were made to insure that the sample size used in this investigation was sufficient for a reasonable probability of detecting differences between treatment levels.

Ostle (32) suggested that researchers interested in adequate sample size should try to answer the following questions (32, p. 149):

1. What is your hypothesis? What are the alternatives?
2. What are you trying to estimate?
3. What significant level are you planning to use? What confidence level?
4. How large a difference do you wish to be reasonably certain of detecting? With what probability?
5. What width confidence interval can you tolerate?
6. What do you expect the variability of your data to be?

After answering these questions, he noted, one would be able to estimate the needed sample size through the use of special tables.

The first and second questions were related to the specific objectives of this study listed in the Introduction Chapter. For answering the third question, a typical significance level of .05 (α = .05) was chosen with 95 percent confidence interval level. To answer question 4, since the size of treatment means was unknown, an estimate of their value was made based on similar experimental studies conducted in Iowa. The "tolerable confidence interval" level requested in question 4, was set at 95 percent. Finally, variability of data was also estimated using similar experimental studies.

Information required in the special tables presented by Ostle (32, p. 569) to estimate the needed sample size was as follows:

1. α level (the probability of committing a Type I error--rejection of a hypothesis which is true). $\alpha = .05$.
2. β level (the probability of committing a Type II error--acceptance of a hypothesis which is false). $\beta = .20$.
3. $D = \frac{\delta}{\sigma}$, where δ = difference between means, and σ = standard

deviation.

The values of differences between treatment means (δ) and standard deviation (σ) as reported in three Iowa studies by Briers (6), Gliem (15), and Townsend (38) were used to estimate the value of D. These researchers used a criterion-referenced test similar to the test used in this study. Therefore, an average of their reported values was chosen to estimate D for this experiment.

In an objective test of knowledge, Gliem (15, p. 50) found a difference between means of about 1.7 with a standard deviation of about 3.4 ($D = \frac{1.70}{3.40} = .50$). Similarly, Briers (6, p. 108) reported a difference between means of 11.03 with a standard deviation of about 9.5 ($D = \frac{11.03}{9.05}$ $= 1.16$). Townsend (38, p. 62) reported a difference between means of 4.30 with standard deviation of approximately 8.30 ($D = \frac{4.30}{8.30} = .51$). The average of these three D values was .72.

For this study, the value of D was set at 1.00 (a rather conservative value). After entering this value to the table given by Ostle (32, p. 569), the needed sample size for each of the two treatment groups (assuming equal sample) was found to be 17. This was smaller than the nineteen teachers assigned to each treatment level in this author's investigation. It was concluded that the sample size used in this study was sufficient to insure a "reasonable probability of detecting differences between treatment means".

The independent variable manipulated by the investigator was the degree to which teachers and their students had access to and used an instructional unit on soil fertility and fertilizers. Two levels of the independent variable were used in this study. The experimental group included those teachers who received and used the instructional unit, while the control group consisted of teachers and their students who did not have access to the instructional unit.

Teachers in the experimental group were provided with the instructional unit along with sufficient copies of the student text, Field Crop Nutrition. They were asked to teach the unit as it was outlined and follow the learning activities provided in the unit.

Teachers who were assigned to the control treatment were not given the instructional unit. Rather, they were provided with only a list of problem areas and study questions outlined in the unit (see Appendix A). This was done for the purpose of equating the subject matter content between two treatment groups. These teachers were asked, however, to use whatever approach they ordinarily use in teaching soil fertility and fertilizers to their students. Both groups were also instructed to collect information from their students before teaching the unit (pretest) and after teaching the unit (posttest).

Instrumentation

In order to measure dependent variables and to collect personal and situational information from the students and their teachers, five instruments were developed. Three instruments were designed to be completed by students, and two instruments were used to collect data from teachers involved in the experiment. A copy of each instrument could be found in Appendix C. The development of the instruments is described in the following paragraphs.

The three instruments used to collect data from students were as follows:

Soil Fertility and Fertilizers Knowledge Inventory: A criterion-referenced test of 40 multiple-choice items with four alternatives each was designed to assess each student's knowledge of soil fertility and fertilizers. The instructional unit was not used in writing the test items because it was not provided to all teachers. As a precaution against bias, the test items were written based on the problem areas, and study questions which had been provided to both groups of teachers. Face and content validity were the two types of validity of major concern for the test. In order to insure content validity, the entire project team evaluated contents of the test based on the problem areas and study questions. To insure face validity, the test was typed and reproduced similar in nature to a common teacher-made test. A copy of the test was then submitted to the staff members in the department of agricultural education at Iowa State University. Test reliability was measured and item analysis was done as part of the experiment. These procedures are explained in the section on analysis of data. The knowledge inventory instrument was administered as a pretest and a posttest, with the items and alternatives for each item randomly arranged for each administration.

Soil Fertility and Fertilizers Attitude Inventory: As mentioned earlier, in the development of the unit, learning activities were designed that would not only enhance student knowledge of the subject matter, but also deal with learner needs and affective domain objectives. To measure each student's attitude toward soil fertility and fertilizers, an attitude inventory instrument was developed. First, six broad concepts which the investigator felt could be dealt with in a soil fertility course were identified. These concepts were importance of testing soils, making decision about fertilizers, safe use of fertilizer materials, importance of applying knowledge to specific situations, being familiar with sources of information, and finally, learning about soil fertility and fertilizers. This latter concept was included in order to obtain students' feelings about the course. Indirectly, this was an indication of the appropriateness of learning activities undertaken in the classroom to teach soil fertility and fertilizers.

The next step was to decide on the type of attitude measurement scale. Review of literature indicated that researchers had used a variety of attitudinal scales. Two researchers in agricultural education had used a technique known as "semantic differential" and reported satisfaction with this technique (24, 27). Semantic differential technique was chosen for this study.

The semantic differential instrument developed for this study consisted of five, seven-step scales bounded by appropriate bipolar adjectives. The bipolar adjectives were taken from among those recommended by Osgood and his associates (31), the originators of the semantic differential technique. The adjectives were selected on the basis of the dimension of meaning they represented, and their appropriateness for the concept being rated. Furthermore, these adjectives were found to be among 50 pairs of bipolar adjectives that had been factor analyzed by Osgood et al. (31) and reported as being appropriate in their "dimension of connotive meaning".

The final step in the development of the attitude inventory instrument was submission of the concepts and their bipolar adjectives to the staff members in the Department of Agricultural Education at Iowa State University for their reactions. Some adjectives had to be removed or changed as the result of this process. Staff members felt those adjectives were difficult to understand by high school-age students. The instrument was also reviewed and approved as being appropriate by Dr. Anton Netusil, statistical specialist in the College of Education at Iowa State University and a member of the author's graduate committee. An example of the concept "testing soil" with its bipolar adjectives appears in Figure 1.

I feel that TESTING SOILS is:

1.	Meaningless:					X			:Meaningful
2.	Unimportant:			X					:Important
3.	Worthless:				X				:Valuable
4.	Foolish:						X		:Wise
5.	Unnecessary:				X				:Necessary

Figure 1. The semantic differential instrument used in the study and a set of hypothetical data

A set of hypothetical data was used in Figure 1 to illustrate how the responses of one individual to each concept appeared on the instrument. Digits were assigned for computational purposes as follows:

Foolish : 1 : 2 : 3 : 4 : 5 : 6 : 7 : Wise

A person's raw score on an item was the digit corresponding to the scale position checked by that individual. In its final format, this instrument contained 30 items which each student had to respond to. The arrangement of items and their bipolar adjectives on the instrument was done randomly. Again, reproduction and format resembled a teacher-constructed measure. This instrument was administered during the pretest and posttest phases of the experiment.

Student Data Questionnaire: This instrument was designed to collect student data related to soil fertility and fertilizers. The 15 student-related questions on the instrument elicited educational plans as well as situational data from each student.

Teacher Data Questionnaire: A 13-item questionnaire was designed to collect data from the teachers who participated in the experiment. Questions were asked to gather personal data, school and vocational agriculture department data, and data related to teachers' educational and occupational experiences. Teachers in both the experimental and control treatment groups completed this instrument at the conclusion of the experiment.

Instructional Unit Evaluation Instrument: This instrument was developed to assess teachers' ratings of the instructional unit. Obviously, only teachers in the experimental treatment group were asked to respond to the items on this instrument. Twenty-three items were included in the instrument (see Appendix C). For the first 11 items, a semantic differential scale (seven step) with two bipolar adjectives were used. Teachers were asked to mark on this semantic differential scale their feelings about the unit in regard to each bipolar adjective. The other items on the instrument were simply statements about the format of the unit such as problem area, study questions, interest approach, etc. Teachers were asked to express their opinion about the value of each item in the format of the unit using the following scale:

No value		Little value		Some value		Much value		Utmost value
/	/	/	/	/	/	/	/	/
1	2	3	4	5	6	7	8	9

Space was provided at the end of this instrument for teachers to record any additional comments or suggestions they might have about the unit.

Collection of Data

Teachers who indicated their willingness to participate in the study were asked to report the anticipated number of students in their soil fertility and fertilizers classes. This information was used by the investigator to mail pretest materials in correct quantities (see Appendix A). Teachers in the experimental group who received the instructional unit were asked to review the materials needed throughout the unit and to order that information which was not currently on hand. Furthermore, these teachers were instructed to proceed through each problem area in the unit and utilize each learning activity provided.

Sufficient copies of the student text Field Crop Nutrition was also provided to these teachers. The control group teachers were mailed an outline of the problem areas and study questions in soil fertility and fertilizers.

Pretest materials mailed to each teacher included adequate copies of the knowledge inventory, and the attitude inventory instruments. General purpose-NCS-answer sheets were provided for the students to record their answers to the pretest questions. Guidelines for collecting student information were provided to teachers in both groups. Teachers were encouraged to ask their building principal or guidance counselor to administer the pretest instruments. Each teacher was asked to return all copies of the original inventory forms and the answer sheets to the investigator immediately after completion.

In addition to completing the instruments used for data collection, each teacher was provided with adequate numbers of an informed consent form to be distributed among students for their signature (see Appendix B). Because the students were minors, parental signatures giving consent were also required. In the same fashion, teachers participating in the experiment were asked to sign an informed consent form (see Appendix B). These forms along with all other data gathering instruments were reviewed and approved by the Iowa State University Committee on the Use of Human Subjects in Research, allowing the investigator to use the data.

All teachers were instructed to notify the investigator approximately two weeks prior to concluding instruction in the unit, so that the posttest materials would be mailed. It became apparent in the process that some teachers were not able to complete all activities before February 1, 1982 (the due date for completing the experiment). Telephone conversation with a sample of teachers indicated that in order to complete all activities, some had planned to teach the unit in the spring semester of 1981-1982 school year. The completion date, therefore, was extended to April 15, 1982.

Shortly before the anticipated completion date, mailings were made with the posttest instruments and directions (see Appendix A). Student and teacher questionnaires were mailed during the posttest phase of the experiment. Teachers in the experimental group were also asked at this time to complete the instructional unit evaluation instrument.

These procedures resulted in obtaining usable data from 27 of the 38 schools: 15 schools in the experimental group and 12 schools in the control group. Attempts were made to identify factors which contributed to this less than 100 percent response rate. Among the factors identified were late arrival of materials, failure to get informed consent signature, and change in vocational agriculture program offering. Furthermore, it was observed that unfavorable weather conditions during the winter of 1982 caused many school cancellations in Iowa which in turn required some adjustments in program offerings by some vocational agriculture teachers in the experiment. This mortality rate may be considered as a threat to internal validity of the experiment; however, results of the informal assessment indicated random loss of respondents from the comparison groups. The use of instructional unit itself was not found to be a factor in the mortality rate.

Analysis of Data

The data collected from the teachers and students were coded and recorded on IBM cards. Analyses were conducted using computer facilities at the Computation Center of the Iowa State University. Two systems of computer programs available at the Computation Center were used for the statistical analyses of data: the Statistical Package for the Social Sciences (SPSS) (29) and the Statistical Analysis System (SAS) (4). In the following paragraphs, an overview of the data modification procedures and statistical routines used in the analyses is presented.

Data modification procedures

As mentioned earlier, in the collection of data, students were provided with General Purpose-NCS-Answer Sheets to record their responses to the pretest and posttest questions on the knowledge inventory instrument. These answer sheets were coded and submitted to the Student Affairs Research Office, Test and Evaluation Services of the Iowa State University for processing. The highest possible score on the knowledge inventory if all items were answered correctly was 40. These raw scores along with student responses on the attitude inventory instrument were coded on IBM cards. Procedures were employed to modify these data in order to accomplish the objectives of the study. First, each student's raw score on the knowledge inventory instrument was converted to a percentage basis using the following formula:

Percentage Score = Raw Score x 2.50

This procedure resulted in the highest possible score of 100 if all the items on the knowledge inventory were answered correctly. Since schools (or classes) were randomly assigned to the treatment groups, the intact class served as the experimental unit to evaluate treatment effects. Therefore, class means were computed to be used for the analysis of the treatment effects.

For the attitude inventory instrument, raw values for each item were recorded on the IBM cards. Again, class means were computed and used as the experimental unit observations. Other data collected from students were also averaged to give class means. This was performed only for the interval-level variables since categorical variables do not lend themselves to means as measures of central tendency. Values for categorical variables (i.e., grade classification level, place of residence, etc.) were used to explain and describe the students (sampling units). Since only one teacher existed for each class, no modification was needed for the teacher data in the statistical analyses.

Descriptive analyses

The dependent variable data gathering instruments were analyzed for consistency. Both the pretest and posttest forms of the knowledge inventory instrument were analyzed for their reliability, item difficulty, and item discriminating power. Reliability estimate was measured by applying the following simplified form of Kuder-Richardson Formula (39, p. 163):

$$\text{K-R 21} = 1 - \frac{\bar{X}\,(n - \bar{X})}{n\,S^2}$$

where:

K-R 21 = Kuder-Richardson reliability coefficient

n = number of items in the test

$\bar{X}$ = mean score on the test

S^2 = test variance (a measure of variability).

To analyze the consistency of the attitude inventory instrument, SPSS subprogram RELIABILITY (29) was used. A reliability coefficient known as reliability coefficient alpha (α) was computed for both pretest and posttest responses to the instrument. The attitude inventory instrument was also factor analyzed using SPSS subprogram FACTOR. The factoring method used for this study is known as PA2-principal factoring with iteration. Nie et al. explained the advantages of this method (29, p. 480):

> It may be noted that PA2 can handle most of the initial factoring needs of the user. At present this is the most widely accepted factoring method. Those who have limited experience with factor analysis might do well to stay with this method.

To analyze and describe categorical variables (student and teacher characteristics), SPSS subprogram FREQUENCIES was employed. In the same fashion, SPSS subprogram CONDESCRIPTIVE was used to analyze and summarize the interval-level variables. Means and standard deviation of selected student and teacher variables were computed by this procedure.

Inferential analyses

In order to identify the differences between pretest mean scores and posttest mean scores, SPSS subprogram T-TEST was used. The particular technique employed for this investigation was PAIRED T-TEST as students were paired for the pretest and posttest administration of the knowledge inventory instrument. In a similar manner, student responses on the attitude inventory instrument were compared using the paired t-test.

SPSS subprogram PEARSON CORR was employed to calculate Pearson product-moment coefficient of correlation for selected interval-level variables. Chi-square statistic was calculated using a command from subprogram CROSSTABS to determine if relationship existed between treatment group and some student and teacher categorical variables. In this analysis, experimental units were considered to be students rather than classes.

SAS procedure GLM was used to analyze the effects of treatment levels on student knowledge of soil fertility and fertilizers (measured by the knowledge inventory instrument) and student attitude toward selected concepts in soil fertility and fertilizers (measured by the attitude inventory instrument). This technique is recommended over procedure ANOVA when unbalanced designs are used in the experiment (4, p. 242). The model used in the analysis of covariance could be symbolically represented as follows:

$$Y_{ij} = \mu + \alpha_i + B1(X_{ij} - X_{..}) + \mathcal{E}_{ij}$$

where:

Y_{ij} = Posttest or gain measurement of the jth school within the ith treatment.

μ = Overall grand mean of the pretest and posttest means.

α_1 = Effect of the ith treatment.

Bl = Regression coefficient.

X_{ij} = Covariate measurement of the jth school within the ith treatment.

$X_{..}$ = Covariate grand mean.

ε_{ij} = Effect due to error.

i = 1,2 for the treatment levels.

j = 1,2, . . . , 15 for schools or classes.

This model permits the analysis of responses by treatment group after adjusting for the effect of pretest.

SPSS subprogram NEW REGRESSION was used to aid in accounting for the variation in the mean posttest scores. The model used in the stepwise regression analysis was:

$$Y_{ij} = B_0 + B_1X_1 + B_2X_2 + \dots\dots + B_kX_k + \varepsilon_{ij}$$

where:

Y_{ij} = Posttest or gain measurement of the jth school within the ith treatment.

B_0 = Y intercept or the height of the regression line at the origin.

$B_1, B_2, \dots, B_k$ = Regression coefficients.

$X_1, X_2, \dots, X_k$ = Independent variables used to predict posttest or gain scores.

ε_{ij} = Effect due to error.

i = 1,2 for the treatment levels.

j = 1,2 . . . ,15 for schools or classes.

Summary of Procedures

The study was conducted during the 1981-1982 school year to evaluate the effectiveness of an instructional unit on soil fertility and fertilizers which was developed to be used by vocational agriculture teachers in Iowa. The effectiveness of the instructional unit was assessed in terms of (1) student knowledge of soil fertility and fertilizer concepts, (2) student attitude towards selected concepts in soil fertility and fertilizers, (3) teacher evaluation of the instructional unit. The independent variable manipulated by the investigator was the extent to which teachers and their students had access to the instructional unit. Two treatment levels were used: (1) teachers were provided with the instructional unit (experimental group), and (2) teachers were not allowed access to the instructional unit (control group).

The design used in the study was a pretest-posttest control group design where the teachers and their students were randomly assigned to each level of the treatment. Pretest measures of the student knowledge and student attitude were collected before the experimental instruction began. At the conclusion of the experiment, information related to (1) student knowledge of soil fertility and fertilizer concepts, (2) student attitude towards some concepts of soil fertility and fertilizers, (3) student background, (4) teacher personal and situational variables, and (5) teacher evaluation of the instructional unit were collected.

Information gathered from the teachers and students was coded and recorded on IBM cards. Analyses were done using the computer facilities at the Computation Center, Iowa State University.

FINDINGS

The main objective of this study was to evaluate the effectiveness of an instructional unit on soil fertility and fertilizers which was developed for use by vocational agriculture teachers in Iowa. In order to accomplish this objective, selected vocational agriculture teachers and their students were randomly assigned to two treatment levels: namely, experimental and control. Teachers in the experimental treatment group used the instructional unit developed by the investigator to teach soil fertility and fertilizers to their students. Teachers in the control group used their own traditional materials and methods to teach the subject matter.

Since the teachers and students who participated in this study were not randomly selected, statistical generalizations of results should not be made beyond the sample group. However, an underlying assumption of this study was that programs used in this investigation are reflective of current vocational agriculture programs in Iowa at the secondary school level and future programs in many cases will follow the same general curriculum pattern.

Results of analyses of responses from schools in each treatment group are presented under the following titles: (1) Descriptive Analyses of Student Characteristics, (2) Descriptive Analyses of Teacher and School Characteristics, (3) Instrument Characteristics, (4) Inferential Analyses Comparing Treatment Groups, (5) Correlation and Regression Analyses of Variables, (6) Analyses of Teachers' Rating of the

Instructional Unit, and (7) Summary of Major Findings.

Descriptive Analyses of Student Characteristics

When nonequivalent groups are used in a pretest-posttest control group design, as much similarity as possible should be established between experimental and control treatment groups. To accomplish this task, student categorical variables and variables expressed as nominal measurements were analyzed. Chi-square statistics were calculated to determine if relationships existed between treatment groups and the criterion variables. Since these variables were not influenced by the treatment itself, students rather than classes were used as experimental units in the analysis.

The number of students and classes in each group which completed the experiment are presented in Table 1. A total of 312 students was

Table 1. Number of students and classes by treatment group

Description	Treatment group					
	Control		Experimental		Total	
	N	%	N	%	N	%
Students	160	51.3	152	48.7	312	100.0
Classes	12	44.4	15	55.6	27	100.0

involved in the experiment. Of these, 152 (48.7%) were in the experimental treatment group and 160 (51.3%) were in the control treatment group. These students were clustered into a total of 27 classes (15 in the experimental group and 12 in the control group).

Data presented in Table 2 revealed that the majority of students (75.6%) lived on farms. Another 8.7 percent lived in a rural area, but not on a farm. The remaining 15.7 percent lived in a town or city.

Table 2. Place of residence by treatment group and chi-square analysis

Place of residence	Treatment group					
	Control		Experimental		Total	
	N	%	N	%	N	%
In a town or city	32	65.3	17	34.7	49	15.7
In a rural area, but not a farm	11	40.7	16	59.3	27	8.7
On a farm	117	49.6	119	50.4	236	75.6
Total	160	51.3	152	48.7	312	100.0

Chi square = 5.33
Signficance = 0.069

No significant relationship existed between the place of residence and the treatment group. This suggests that the students in the two groups were homogeneous with reference to the place of residence.

The place of residence of students who participated in this study is further described in Figure 2.

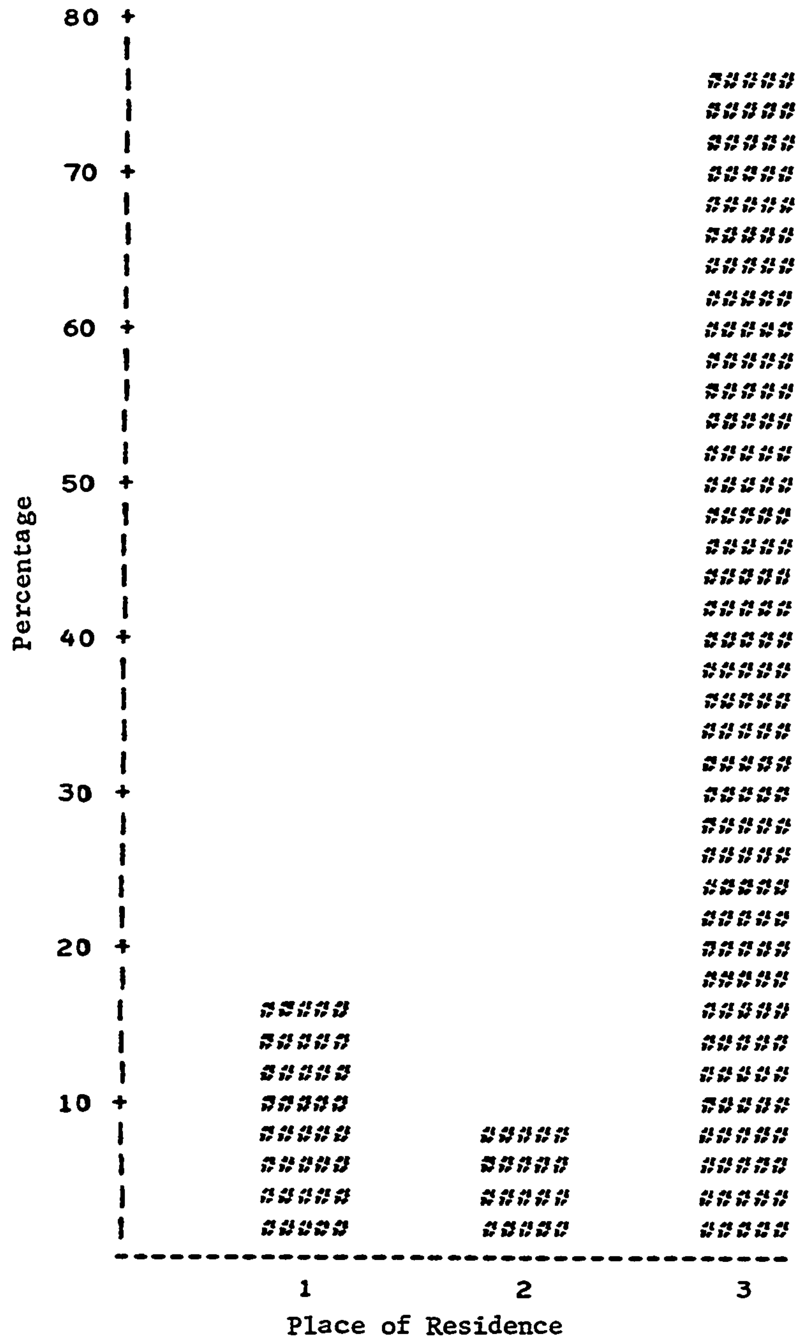

Figure 2. Place of student residence (1 = town or city, 2 = rural area, but not a farm, 3 = farm)

Another situational variable investigated was the student grade level. Descriptive summary of this analysis is presented in Table 3.

Table 3. Student grade level by treatment group and chi-square analysis

Grade level	Treatment group				Total	
	Control		Experimental			
	N	%	N	%	N	%
Freshman (9th grade)	3	14.3	18	85.7	21	6.7
Sophomore (10th grade)	145	53.9	124	46.1	269	86.2
Junior (11th grade)	8	44.4	10	55.6	18	5.8
Senior (12th grade)	4	100.0	0	0.0	4	1.3
Total	160	51.3	152	48.7	312	100.0

Chi-square = 16.38
Significance = 0.000

The majority of students (86.2 percent) were classified as sophomores. There were only 4 seniors in this study. These seniors were in the control group. The remaining students were classified as either freshman (6.7 percent) or junior (5.8 percent). The relatively large chi-square (16.38 with 3 degrees of freedom) indicated the existence of a significant relationship between student grade level and the treatment group. However, when the chi-square analysis was inspected more closely, it was observed that 2 out of 8 (25 percent) cells had expected frequencies less than 5. When expected cell values are small (i.e., less than 5), such values lead to producing large chi-square values. In order to reduce the effect of small cell values, the researcher decided to combine the number of seniors and juniors to form a single grade level. This decision was based on the fact that there were only 4 seniors in the control group and none in the experimental treatment group. Results of cross tabulation analysis after making this adjustment are presented in Table 4.

Table 4. Combined grade level by treatment group and chi-square analysis

Grade level	Treatment group: Control N	%	Experimental N	%	Total N	%
Freshman	3	14.3	18	85.7	21	6.7
Sophomore	145	53.9	124	46.1	269	86.2
Junior and senior	12	54.5	10	45.5	22	7.1
Total	160	51.3	152	48.7	312	100.0

Chi-square = 12.34
Significance = 0.002

A significant relationship was found between student grade level and the treatment group based on data presented in Table 4. This observation suggests that the students in the two groups were not homogeneous with reference to their grade level. Since student grade level at school might have an effect on the score received on a soil fertility test, further investigation is warranted.

A chi-square analysis of data presented in Table 5 revealed a small chi-square value suggesting that no relationship existed between grades received by students and treatment group. In other words, treatment groups were homogeneous in regard to grades students normally received in school. It was further observed that the distribution of grades received by students were almost normal (see Figure 3). The majority of students reported that they normally received B or C grades in school.

Table 5. Grades normally received by treatment group and chi-square analysis

Grades	Treatment group					
	Control		Experimental		Total	
	N	%	N	%	N	%
Mostly As	24	49.0	25	51.0	49	15.7
Mostly Bs	59	50.4	58	49.6	117	37.5
Mostly Cs	66	52.0	61	48.0	127	40.7
Mostly Ds	11	57.9	8	42.1	19	6.1
Total	160	51.3	152	48.7	312	100.0

Chi-square = 0.49

Significance = 0.920

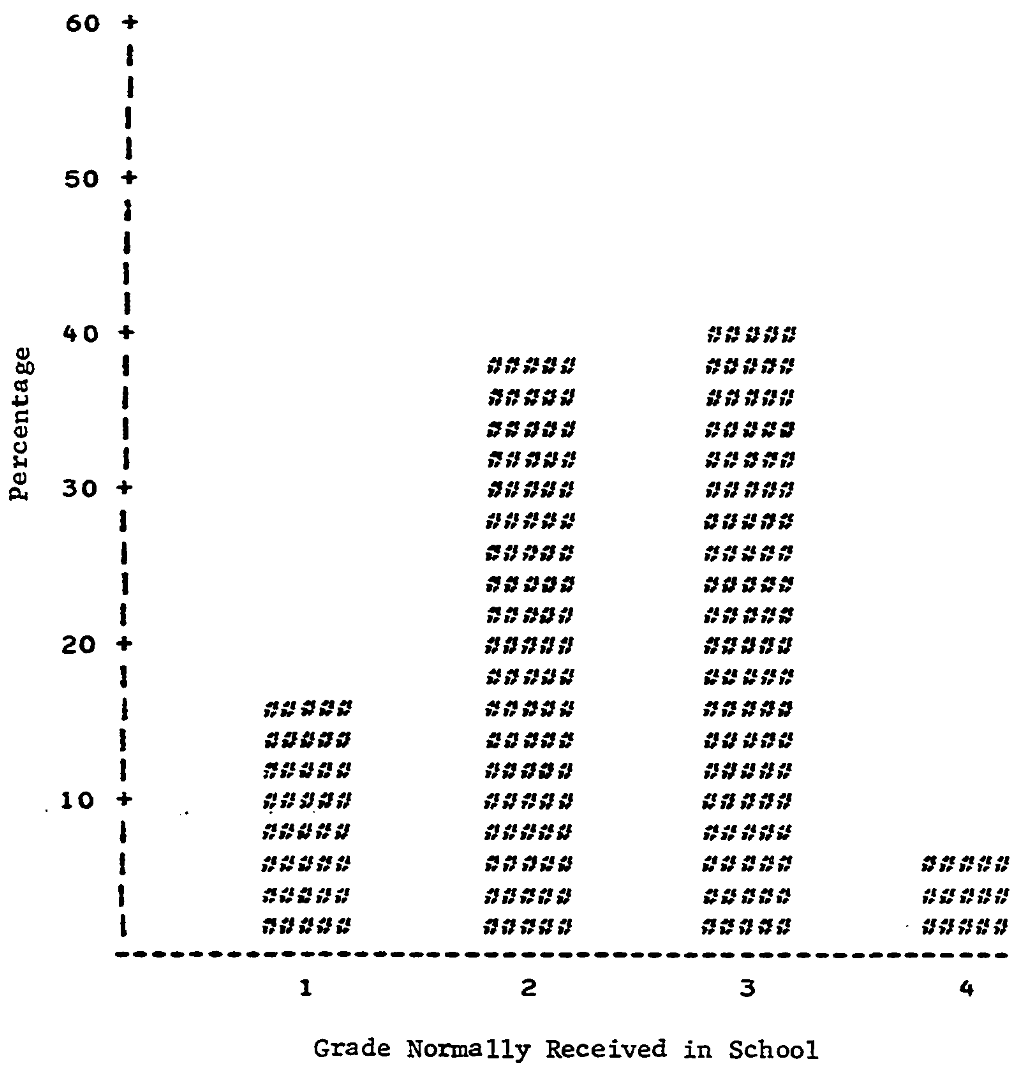

Figure 3. Student grade distribution (1 = mostly As, 2 = mostly Bs, 3 = mostly Cs, 4 = mostly Ds)

The final categorical variable investigated was students' immediate plan upon graduating from high school. Results of the analysis of this variable are summarized in Table 6. The majority of students (34.9 percent) indicated that they planned to attend college after graduating from high school. Approximately 26 percent (26.3%) of the students wanted to farm, whereas 21.8 percent of students were still undecided about their future careers. Only 3.2 percent of the students studied indicated that they planned to work in an agricultural business after high school graduation.

Table 6. Students' plans after graduation by treatment group and chi-square analysis

Plans	Treatment group				Total	
	Control		Experimental			
	N	%	N	%	N	%
Go to college	51	46.8	58	53.2	109	34.9
Farm	43	52.4	39	47.6	82	26.3
Work in agribusiness	7	70.0	3	30.0	10	3.2
Work, but not in agribusiness	12	54.5	10	45.5	22	7.1
Enter the military	7	33.3	14	66.7	21	6.7
Undecided	40	58.8	28	41.2	68	21.8
Total	160	51.3	152	48.7	312	100.0

Chi-square = 6.67

Significance = 0.245

Chi-square analysis detected no relationship between students' plans after graduation and treatment group. In other words, student plan after graduation was independent of the treatment group. The percentage of students in each category are graphically shown in Figure 4.

Several student personal and situational variables were measured on ratio or interval scales. These variables were: (1) years of FFA membership, (2) semesters of vocational agriculture classes completed, (3) semesters of economic or business classes completed, (4) semesters of science classes completed, (5) semesters of mathematics classes completed, and (6) size of family farm. Results of the analysis of these variables are presented in Table 7.

Selection of the appropriate t-value for each of the variables in Table 7 was based on the test of equality of variances (F-test). Separate estimate t-value was used when the F-value was significant (at .05 level). The pooled t-value was used when the F-value was not significant.

Two out of six t-values reported in Table 7 were observed to be significant. These t-values were reported for semesters of vocational agriculture and semesters of economics or business classes completed by students. Students in the control group had completed more vocational agriculture classes than had their counterparts in the experimental group (mean of 3.38 vs. 3.02). The same was true for the mean number of semesters of economics and business classes completed. Students in the control group had completed more semesters of economics and business than had students in the experimental group. Since these two variables

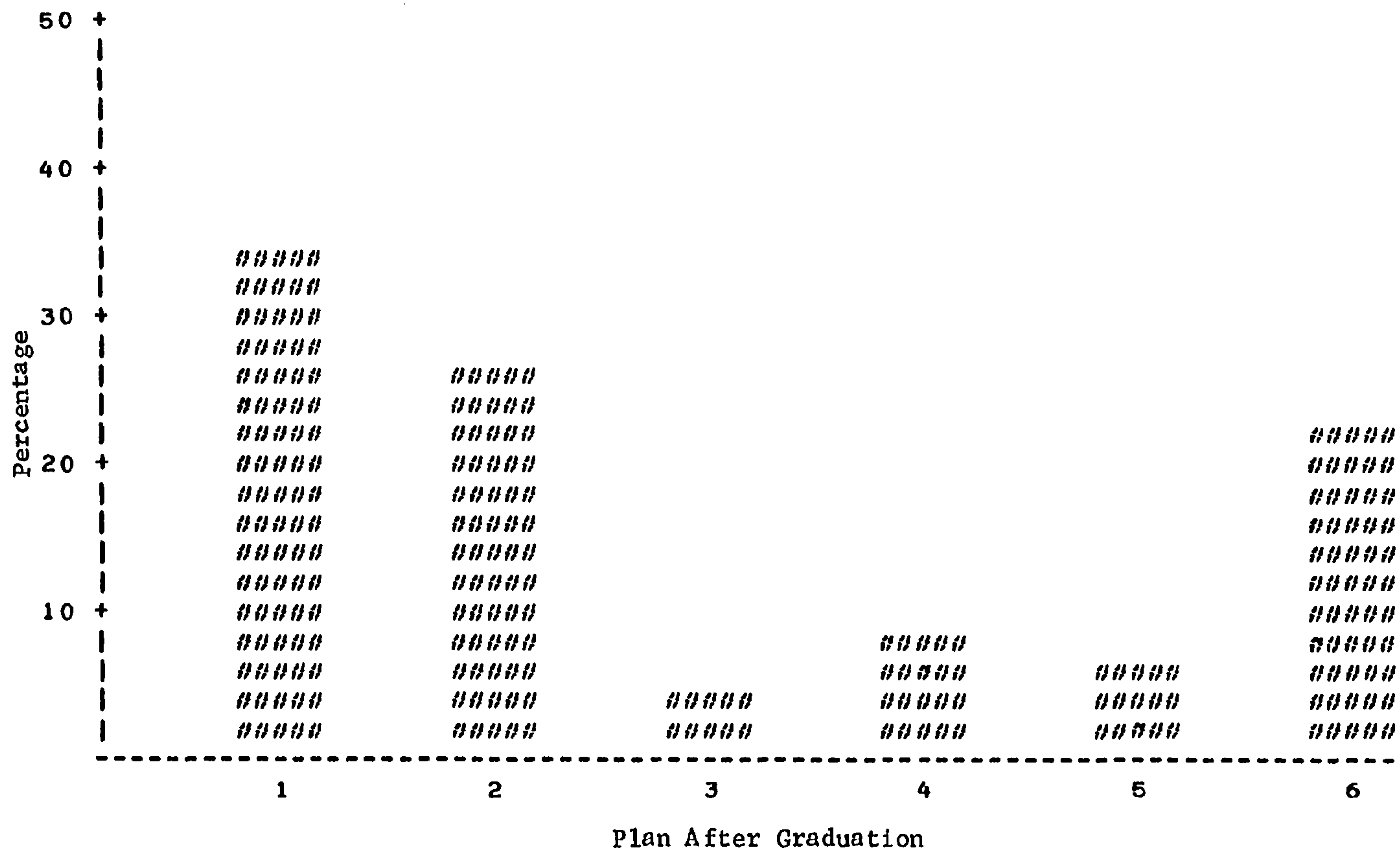

Figure 4. Plans of students after high school graduation (1 = go to college, 2 = farm, 3 = work in agribusiness, 4 = work, but not in agribusiness, 5 = enter military, 6 = undecided)

Table 7. Means, standard deviations, number of respondents, and t-values for selected student personal and situational variables by treatment group

Variable	Overall (N=312)	Treatment group: Control (N=160)	Treatment group: Experimental (N=152)	t-value	Probability
	Mean S.D.	Mean S.D.	Mean S.D.		
Years of FFA membership	1.87 0.53	1.92 0.61	1.93 0.42	1.62	0.107[a]
Semesters of vocational agriculture	3.20 1.03	3.38 1.07	3.02 0.96	3.13	0.002[b]
Semesters of economics or business	0.80	1.00	0.59	2.79	0.006[a]
Semesters of science	3.22 1.42	3.31 1.52	3.12 1.30	1.17	0.243[a]
Semesters of mathematics	2.89 1.32	2.89 1.35	2.89 1.29	-0.01	0.995[b]
Size of family farm (acres)	345.14 373.72	345.32 383.82	344.95 364.06	0.01	0.993[b]

[a] Separate variance estimate of t-values was used.

[b] Pooled variance estimate of t-values was used.

might have an effect on student performance in a soil fertility class, further investigation was warranted. Because the other t-values were not significant, the investigator concluded that, for those variables, the groups were homogeneous.

In summary, the analyses of student data indicated that the two treatment groups were homogeneous on the following situational and personal variables: student place of residence, grades normally received in school, plans after graduation, size of family farm, years of FFA membership, and semesters of science or mathematics completed. Treatment groups were not homogeneous with regard to the student grade level, semesters of vocational agriculture completed, and semesters of economics or business completed. It was further concluded, because of the homogeneity of both groups, that both groups had reacted similarly to instruction in soil fertility and fertilizers.

Descriptive Analyses of Teacher and School Characteristics

Overall, 27 teachers representing the same number of schools were involved in the experiment. Fifteen teachers used the instructional unit (experimental group) and twelve teachers used their own methods and materials to teach soil fertility and fertilizers (control group). Because personal characteristics of the vocational agriculture teachers and the school situations in which they taught might affect the teaching-learning process, these characteristics were examined to determine similarities or differences between treatment groups.

Teachers who participated in the experiment were asked to provide answers to the following questions: (1) How many years have you taught vocational agriculture? (2) How many students are enrolled in your high school? (3) How many students are enrolled in the vocational agriculture department? (4) How many day classes do you teach? (5) How many vocational agriculture classes do you teach? (6) What is the highest level of your education? (7) Did you take a college course that focused on soil fertility and fertilizers? (8) On a scale of 1 to 5, how would you rate your general knowledge of soil fertility? (9) Have you had any experience in a fertilizer-related business? (10) What was the length of experience? These data were analyzed using t-test or chi-square depending on the scale of measurement.

Summary analyses of the teacher and school variables which measured on a ratio or interval scale are presented in Table 8.

Vocational agriculture teachers participating in this study had a mean of 10.8 years of teaching experience, were teaching an average of 4.8 classes each day, and had an average of 8.3 months experience in a fertilizer-related business. Data presented in Table 8 revealed that teachers in the two treatment groups were not significantly different with respect to these variables. In terms of high school and vocational agriculture enrollment, the control group had the lowest mean enrollment. The difference, however, was not significant. Overall mean school enrollment and vocational agriculture departmental enrollment were about 298 and 60 students, respectively.

In order to assess the vocational agriculture teacher's knowledge

Table 8. Means, standard deviations, number of respondents, and t-values for selected teacher and school characteristics by treatment group

Variable	Overall (N=27)	Treatment group: Control (N=12)	Treatment group: Experimental (N=15)	t-value	Probability
	Mean S.D.	Mean S.D.	Mean S.D.		
Total years teaching experience	10.82 11.02	9.58 10.28	11.86 11.84	-0.53	0.603[a]
High school enrollment	298.26 187.58	294.08 187.59	301.60 194.08	-0.10	0.920[a]
Departmental enrollment	59.59 31.97	53.42 20.71	64.53 38.76	-0.95	0.351[b]
Number of classes taught	4.78 0.89	4.83 0.83	4.73 0.96	0.28	0.778[a]
Number of Vo. Ag. classes taught	4.59 0.84	4.58 0.79	4.60 0.91	-0.05	0.961[a]
Knowledge of soil fertility	3.92 1.14	3.75 1.60	4.07 0.59	-0.65	0.527[b]
Months of business experience	8.33 15.93	5.83 14.10	10.33 17.48	-0.72	0.477[a]
Enrollment in soil fertility class	11.55 5.51	13.33 6.81	10.13 3.80	1.54	0.136[a]

[a]Pooled variance estimate of t-value was used.

[b]Separate variance estimate of t-value was used.

of soil fertility, teachers were asked to rate their general knowledge of the subject on a 1 (low) to 5 (high) scale. Although teachers in the experimental group rated this item high (mean of 4.07 compared with 3.75 for the control group), the difference was not significant. Since none of the t-values reported in Table 8 were significant, the investigator concluded that the two groups were similar with respect to these variables.

Three teacher personal variables were measured on a nominal scale. The summary analyses of these variables are presented in Table 9.

The majority of teachers (40.7 percent) had some formal education beyond their baccalaureate degree. Only 8 teachers had a master's degree or more. Expected cell frequencies for several categories were low (below 5). For the variable "education," the last category (M.S. + 15) was combined with "M.S." to increase expected cell frequencies to justify the use of the chi-square test. The chi-square test of independence was not significant (at 0.05 level) when the data was tested using collapsed cells. It should be noted that in Table 9 for the variables entitled "agribusiness" and "college course on soils," a phi statistic (ϕ) is reported.

According to Nie et al. (29, p. 224):

> For a 2 x 2 table, the phi statistic is a suitable measure of association, i.e., a measure of strength of relationship. Phi (ϕ) makes a correction for the fact that the value of chi-square is directly proportional to the number of cases N by adjusting the (χ^2) value. . . . Phi takes on the value of 0 when no relationship exists, and the value of +1 when the variables are perfectly related.

Table 9. Selected personal characteristics of vocational agriculture teachers by treatment group

Grade level	Treatment group					
	Control		Experimental		Total	
	N	%	N	%	N	%
Education						
B.S.	5	62.5	3	37.5	8	29.6
B.S. + 15	4	36.4	7	63.6	11	40.7
M.S.	3	42.9	4	57.1	7	25.9
M.S. + 15	0	0.0	1	100.0	1	3.7
Total	12	44.4	15	55.6	27	100.0
				Chi-square = 2.15 Significance = 0.541		
Agribusiness experience?						
Yes	4	44.4	5	55.6	9	33.3
No	8	44.4	10	55.6	18	66.7
Total	12	44.4	15	55.6	27	100.0
				Phi = 0.0		
College course on soils?						
Yes	10	43.5	13	56.5	23	85.2
No	2	50.0	2	50.0	4	14.8
Total	12	44.4	15	55.6	27	100.0
				Phi = 0.046		

Because none of the tests reported in Table 9 were significant, the conclusion was made that these teacher variables were independent of the treatment groups to which the teachers were assigned.

In summary, the analysis of teacher and school variables indicated that these variables were independent of the treatment group. The random assignment of teachers/schools to treatment groups successfully affected homogeneity between the groups for the selected variables measured.

Instrument Characteristics

Two instruments which were used to assess students' knowledge of soil fertility and fertilizers and students' attitude toward selected concepts in soil fertility and fertilizers were analyzed for their reliability. Item and factor analyses were also performed on the instruments. The results of these procedures are presented in the following sections.

Soil Fertility and Fertilizers Knowledge Inventory

Both pretest and posttest forms of the knowledge inventory instrument were analyzed. Summary statistics which were calculated for the knowledge inventory instrument are shown in Table 10.

Table 10. Descriptive summary of soil fertility and fertilizers knowledge inventory instrument

Characteristics	Pretest	Posttest
Mean score (raw score)	23.74	29.42
Standard error of measurement	2.72	2.34
Standard deviation	6.99	8.14
Mean item difficulty	0.59	0.74
Mean item discriminating power	0.39	0.50
KR - 20 reliability estimate	0.85	0.92

It was observed that the reliability coefficient (KR-20 reliability estimate) for the pretest and posttest forms of the instrument were .85 and .92, respectively. On the average, students answered correctly 59 percent of the items on the pretest and 74 percent of the items on the posttest. The item difficulty means were .59 and .74 for the pretest and posttest forms of the inventory, respectively. The most important statistic revealed in Table 10 was the mean item discriminating power. This value was actually the correlation between the student response on a specific item and that student's total score on the test. This statistic reflects the extent to which test items discriminate between knowledgeable and less knowledgeable students. The mean item discriminating power was .39 for the pretest and .50 for the posttest forms of the instrument. Individual item analysis indicated that all 40 items had positive values for discriminating power and all were above .10 for both pretest and posttest forms of the instrument. Individual item analysis of the knowledge inventory instrument could be found in Appendix D.

Soil Fertility and Fertilizers Attitude Inventory

The Soil Fertility and Fertilizers Attitude Inventory consisted of 30, seven-step items each bounded by appropriate bipolar adjectives. This semantic differential instrument was designed to assess students' attitudes toward six broad concepts in soil fertility and fertilizers. For each of the six concepts being measured, five items and their appropriate bipolar adjectives were included making a total of 30 items on the instrument. Each of the six concepts and their items were considered as a subscale and analyzed as such. The reliability coefficient (coefficient alpha) for the pre- and postexperiment administration of each of the subscales were computed. The results of these analyses are reported in Table 11.

Table 11. Reliability estimate (coefficient alpha) of the attitude inventory instrument

Subscale	Concept	Number of items	Pretest	Posttest
1	Importance of testing soil	5	0.92	0.92
2	Making fertilizer decisions	5	0.87	0.68
3	Safe use of fertilizer materials	5	0.79	0.64
4	Learning about soil fertility	5	0.76	0.65
5	Applying general knowledge to specific situations	5	0.72	0.67
6	Being familiar with sources of information	5	0.80	0.74
Overall		30	0.93	0.92

Although the overall reliability estimate was high (.93 and .92 for the pretest and posttest administration of the instrument, respectively), the reliability for several subscales (concepts) were low. In order to examine the inventory more completely, factor analysis was performed separately on the pretest and posttest measures. Results of this procedure are presented in Table 12.

Table 12. Summary of attitude inventory instrument factor analysis

Subscale	Pretest			Posttest		
	Factor	Eigen-value	% variation	Factor	Eigen-value	% variation
1	1	3.57	100.0	1	3.56	100.0
2	1	2.85	73.3	1	2.07	66.9
	2	1.04	26.7	2	1.03	33.1
3	1	3.16	94.4	1	2.85	94.3
	2	0.19	5.6	2	0.17	5.7
4	1	2.60	91.8	1	2.51	94.1
	2	0.23	8.2	2	0.16	5.9
5	1	1.98	57.7	1	2.08	59.3
	2	1.45	42.3	2	1.42	40.7
6	1	3.65	95.1	1	3.43	93.7
	2	0.19	4.9	2	0.23	6.3

The underlying assumption of this inventory was that each of the subscales were measuring one factor (or in this case one concept of soil fertility). However, as was observed in Table 12, results of factor analysis indicated the existence of a second factor in several cases. Although the percent variation for the second factor was low, the decision was made to examine those items with low factor loadings on the first factor and high factor loadings on the second factor. To determine the effect of those low-loading items on the reliability of the attitude inventory instrument, seven of the original 30 items which also showed low item-scale correlation were deleted to form a new modified attitude scale. Estimates of reliability coefficient alpha were computed for each subscale. The results of these tests are presented in Table 13.

Reliability analysis of the modified instrument revealed significant increases in the value of coefficient alphas. The overall reliability

Table 13. Reliability estimates (coefficient alpha) of the modified attitude inventory instrument

Subscale	Concept	Number of items	Pretest	Posttest
1	Importance of testing soil	5	0.92	0.92
2	Making fertilizer decisions	3	0.91	0.84
3	Safe use of fertilizer materials	4	0.93	0.89
4	Learning about soil fertility	4	0.85	0.81
5	Applying general knowledge to specific situations	3	0.83	0.82
6	Being familiar with sources of information	4	0.92	0.91
Overall		23	0.95	0.95

estimate increased from .92 (for the original scale) to .95 for the modified scale). Although the increase in the overall reliability estimate was not high, several values for subscales were considerably high. The decision was made to use the modified version of the attitude inventory scale in the analyses of dependent variables measured by this instrument.

Because several subscale items were added together, it was necessary to appraise the instrument for scale additivity. Tukey's test of additivity (29, p. 253) was performed on each subscale of the instrument. Furthermore, Hotelling's T-square method (29, p. 254) was performed to test for the homogeneity of item variances. The results of these tests satisfied the conditions for scale additivity.

Intercorrelations among the items in each subscale were then inspected. Except for those items which were dropped to form a modified scale, item intercorrelations were positive and homogeneous. Further information regarding the results of the attitude inventory instrument analysis are provided in Appendix D.

In summary, the analyses of the dependent variable data gathering instruments revealed that the knowledge inventory had a good internal consistency as measured by KR-20 reliability coefficient. The attitude inventory instrument, on the other hand, was found to have low internal consistency on several subscales as measured by Cronbach's reliability coefficient alpha. After several low factor loading items were dropped, the analyses of the modified instrument indicated reasonable consistency.

Inferential Analyses Comparing Treatment Groups

The purpose of this study was to evaluate the effectiveness of an instructional unit on soil fertility and fertilizers. The first three objectives of the study were to (1) determine if use of this unit would significantly increase student's knowledge of soil fertility and fertilizers, (2) determine effects of using this unit as compared with instructional materials traditionally used by vocational agriculture teachers, and (3) identify changes in student attitudes as a result of using this unit.

For each of the above objectives, several hypotheses were tested using an appropriate inferential statistic. Because the dependent variables were assumed to be influenced by the treatment, class means were used in these analyses. Experimental units were considered to be classes.

Comparison of knowledge scores

The first objective was to determine if the use of the instructional unit would significantly increase students' knowledge of soil fertility and fertilizers. The hypotheses to be tested were as follows:

Ho_1: There is no significant difference between pretest and posttest knowledge scores for the experimental treatment group.

Ho_2: There is no significant difference between pretest and posttest knowledge scores for the control treatment group.

Ho_3: There is no significant difference between combined treatment pretest and posttest knowledge scores.

Paired t-tests were performed to test these null hypotheses. Results of these analyses are summarized in Table 14.

Table 14. Knowledge score means, standard deviations and t-values by treatment group

Treatment group	N	Knowledge score				t-value	Probability
		Pretest		Posttest			
		Mean	S.D.	Mean	S.D.		
Experimental	15	55.09	7.82	81.79	9.21	23.07	0.000
Control	12	48.78	7.76	67.41	15.36	4.11	0.002
Combined	27	52.29	8.28	75.40	14.09	10.46	0.000

The mean pretest score of the experimental group was higher than that of the control group (58.78 vs. 55.09). The standard deviation, however, was almost identical for both groups (7.82 and 7.76 for the experimental and control groups, respectively). Similar observations were made when mean posttest scores were analyzed. The standard deviation of the posttest scores for the experimental group was less than that of the control group revealing more uniformity among the posttest scores of the experimental group. Overall, the mean combined pretest score was 52.29 which increased to 75.4 during the postadministration of the knowledge test. Furthermore, the standard deviation for the combined posttest scores was higher than the standard deviation for the pretest scores (14.09 vs. 8.28 for posttest and pretest, respectively).

The paired t-test procedure was used to test for significant differences between pretest and posttest means. The t-value for testing the equality of means (first hypothesis) was significant beyond $P = .01$. The t-value of 23.07 with 14 degrees of freedom revealed that pretest and posttest means of the experimental group differed significantly. The first null hypothesis was rejected and the alternative hypothesis was accepted. There was a significant difference between pretest and posttest knowledge scores for the experimental group.

The second t-value in Table 14 was also significant beyond $P = .01$. The t-value of 4.11 with 11 degrees of freedom revealed that the pretest and posttest mean scores differed significantly for the control group. The second null hypothesis was rejected and the alternative hypothesis was accepted. There was a significant difference between pretest and posttest knowledge scores for the control group.

The third hypothesis implied a test for the difference between combined treatment pretest and posttest knowledge scores. With $\alpha = .01$, the third t-value in Table 14 was significant. The third null hypothesis was rejected and the alternative hypothesis was accepted. There was a significant difference between combined treatment pretest and posttest knowledge scores.

The second objective of this study was to determine the effect of using the instructional unit as compared with instructional materials traditionally used by vocational agriculture teachers. The null hypothesis tested was as follows:

> Ho_4: There is no difference between treatment posttest scores after variations due to pretest scores are removed.

The statistical design used was an analysis of covariance with one-factor (treatment) and one covariate (pretest knowledge score). The model used could be symbolically represented as:

$$Y_{ij} = \mu + \alpha_i + B1(X_{ij} - X_{..}) + \epsilon_{ij}$$

where:

Y_{ij} = Posttest knowledge score of the jth school within the ith treatment.

μ = Overall grand mean.

α_i = Effect of the ith treatment.

B1 = Regression coefficient.

X_{ij} = Covariate (pretest) measurement of the jth school within the ith treatment.

$X_{..}$ = Covariate grand mean.

i = 1,2 for the treatment levels (experimental and control).

j = 1,2, . . . , 15 for schools or classes.

This model permits the analysis of posttest scores by treatment group after adjusting for pretest differences.

SAS procedure GLM (General Linear Models procedure) was used to test the statistical significance of differences between posttest scores. This technique is recommended when unbalanced designs are used in the experiment instead of analysis of variance procedure which is suitable for balanced data (4, p. 242). Results of the analysis of covariance using the GLM procedure are presented in Table 15.

Table 15. Analysis of covariance for posttest knowledge score comparing treatment groups using pretest as the covariate

Source of variation	Degrees of freedom	Sums of squares	Mean square	F-value	Prob.
Model	2	2253.89	1126.95	9.30	0.00
Treatment (unadjusted)	1	1377.32	1377.32	11.36	0.00
Treatment (adjusted for the covariate)	1	521.37	521.37	4.30	0.04
Covariate (pretest score)	1	876.57	876.57	7.23	0.01
Error	24	2908.84	121.20		

Four F-values are reported in Table 15. The first F-value is the ratio produced by dividing mean square (model) by mean square (error). It tests how well the model as a whole accounts for the dependent variable (posttest score) variation. The second F-value reflects the effect of treatment if the variations in the posttest scores due to pretest are not adjusted. These two comparisons, however, were not of primary importance for testing the null hypothesis previously stated. More important was the difference between treatment group posttest scores after adjusting for the covariate. The third F-value in Table 15 was significant at 0.05 level. The null hypothesis was therefore rejected and the alternative hypothesis was accepted. There was a significant difference between treatment posttest scores after variations due to pretest scores were removed.

Earlier in this chapter, analyses of student characteristics revealed that treatment groups were not homogeneous with regard to the semesters of vocational agriculture and semesters of economics completed by students in each group. Since these findings suggested dissimilarity between treatment groups, the investigator decided to use these two variables (semesters of vocational agriculture and economics completed) as covariates in the model described previously. Results of the analysis of covariance test using these two additional variables as covariates are summarized in Table 16. The third F-value reported in Table 16 was significant beyond .05 level. The treatment effect was still significant after the variation due to pretest scores, semesters of vocational agriculture, and semesters of economics were removed. Again, the investigator rejected the null hypothesis and accepted the alternative hypothesis.

Comparison of responses to the attitude inventory instrument

The third objective of this study was to identify changes in student attitudes as a result of using the instructional unit. Measures of student attitude toward selected concepts in soil fertility and fertilizers was another criterion by which the instructional unit was evaluated.

Table 16. Analysis of covariance for posttest score comparing treatment groups using semesters of economics, semesters of vocational agriculture, and pretest scores as the covariates

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Model	4	3985.85	996.46	18.63	0.00
Treatment (unadjusted)	1	1377.32	1377.32	25.75	0.00
Treatment (adjusted for covariates)	1	230.81	230.81	4.31	0.04
Covariate 1 (pretest score)	1	825.12[a]	825.12	15.42	0.00
Covariate 2 (semesters of vocational agriculture)	1	134.09[b]	134.09	2.51	0.12
Covariate 3 (semesters of economics)	1	1488.55	1488.55	27.83	0.00
Error	22	1176.89	53.49		

[a]Sums of square adjusted for the semesters of vocational agriculture and semesters of economics.

[b]Sums of square adjusted for the semesters of economics.

As with the knowledge scores, the three null hypotheses tested were as follows:

Ho_5: There is no significant difference between pretest and posttest attitude scores for the experimental treatment group.

Ho_6: There is no significant difference between pretest and posttest attitude scores for the control treatment group.

Ho_7: There is no significant difference between combined treatment pretest and posttest attitude scores.

In comparing the pretest and posttest measures, student responses to all items in the attitude inventory instrument were averaged to

Obtain a mean response. The following formula was used in the computation process:

$$\text{Overall response} = \frac{\sum_{i=1}^{23} X_i}{23}$$

where:

X = Student response to each item in the instrument ranging from 1 to 7, and

i = Number of items on the modified attitude inventory instrument (i = 23).

This computation resulted in an overall pretest and posttest attitude score ranging from minimum of 1 to maximum of 7 for each student. Class means, however, were used in the analyses of pretest and posttest measures. Results of these analyses are reported in Table 17.

Table 17. Attitude score means, standard deviations and t-values by treatment group

Treatment group	N	Attitude score: Pretest		Posttest		t-value	Probability
		Mean	S.D.	Mean	S.D.		
Experimental	15	5.88	0.64	6.18	0.74	3.02	0.009
Control	12	5.86	0.35	5.80	0.46	-0.38	0.709
Combined	27	5.87	0.52	6.01	0.65	1.49	0.147

Data presented in Table 17 revealed that classes in the experimental treatment had a pretest mean score of 5.88 with a standard deviation of 0.64. Classes in the control treatment had a pretest mean score of 5.86 with a standard deviation of 0.35. For the postexperiment administration of the instrument, classes in the experimental treatment had a mean score of 6.18 with a standard deviation of 0.74, whereas classes in the control treatment had a score of 5.80 with a standard deviation of 0.46.

The paired t-test procedure was used to test for significant differences between pretest and posttest means. The first t-value reported in Table 17 was significant beyond $P = .01$. The t-value of 3.02 with 14 degrees of freedom revealed that the experimental treatment pretest and posttest mean scores differed significantly. Null hypothesis number 5 (Ho_5) was rejected and the alternative hypothesis was accepted. There was a significant difference between pretest and posttest attitude mean scores for the experimental group.

Hypothesis number 6 (Ho_6) implied a test of differences between pretest and posttest attitude mean scores for the control group. Because the second t-value in Table 17 was not significant, the investigator failed to reject the null hypothesis. Finally, analysis for testing hypothesis number 7 (Ho_7) yielded a t-value of 1.49 with 26 degrees of freedom which did not surpass the critical value ($P < .05$). Ho_7 was not rejected.

In order to observe the attitude scores more closely, pretest and posttest mean scores for each of the selected concepts in soil fertility and fertilizers were analyzed for both treatment groups. Results of these analyses are presented in Table 18 and Table 19. None of the t-values reported in Table 18 were significant at the .05 level, whereas several t-values in Table 19 were significant. The large t-values in Table 19 were related to the differences between pretest and posttest scores for the following concepts: (1) making fertilizer decisions, (2) learning about soil fertility and fertilizers, (3) applying general knowledge to specific situations, and (4) being familiar with sources of information. For these concepts, posttest mean scores were significantly different than pretest mean scores.

Caution should be used in interpreting the t-values reported in Table 19. Although data analyses revealed several significant ($P < .05$) and highly significant ($P < .01$) t-values, correlational analyses indicated high intercorrelation among concepts. Statistically, in such instances where items (or in this case, concepts) are intercorrelated, one should look at the t-values in Table 19 in terms of a concept known as "experiment-wise error rate". According to Hinkle et al. (17, p. 270): "An experiment-wise error rate is defined as the probability of making at least one Type I error per set of all possible comparisons in an experiment." This error-rate which is designated as α_E could be calculated using the following formula (17, p. 270):

$$\alpha_E = 1 - (1 - \alpha)^c$$

where:

α_E = Experiment-wise error rate

α = Type I error

c = Number of possible comparisons.

Table 18. Pretest and posttest group means, standard deviations, and t-values for control group attitude toward selected concepts in soil fertility and ferilizers

Subscale concept measured	Attitude scores				t-value	Probability
	Pretest (N=12)		Posttest (N=12)			
	Mean	S.D.	Mean	S.D.		
1. Importance of testing soil	5.94	0.40	5.81	0.46	-0.86	0.411
2. Making fertilizer decisions	6.10	0.42	5.89	0.53	-1.44	0.177
3. Safe use of fertilizer materials	6.29	0.44	6.13	0.62	-0.97	0.350
4. Learning about soil fertility and fertilizers	5.36	0.64	5.50	0.41	0.65	0.526
5. Applying general knowledge to specific situations	5.53	0.48	5.58	0.47	0.27	0.796
6. Being familiar with sources of information	5.84	0.55	5.86	0.45	0.10	0.926
Overall response	5.86	0.35	5.80	0.46	-0.38	0.709

Table 19. Pretest and posttest means, standard deviations, and t-values for experimental group attitude toward selected concepts in soil fertility and fertilizers

Subscale concept	Attitude score: Pretest (N=15)		Attitude score: Posttest (N=15)		t-value	Probability
	Mean	S.D.	Mean	S.D.		
1. Importance of testing soil	5.97	0.42	6.20	0.83	1.46	0.166
2. Making fertilizer decisions	5.98	0.69	6.38	0.51	4.93	0.000
3. Safe use of fertilizer materials	6.35	0.60	6.47	0.61	1.18	0.258
4. Learning about soil fertility and fertilizers	5.49	0.72	5.85	0.81	2.26	0.040
5. Applying general knowledge to specific situations	5.53	0.84	5.92	0.79	3.61	0.003
6. Being familiar with sources of information	5.88	0.84	6.17	0.91	2.77	0.015
Overall response	5.88	0.64	6.18	0.74	3.02	0.009

When this formula was applied to the concepts and comparisons reported in Table 19, α_E was found to be 0.26. Dividing α_E by the number of comparisons resulted in obtaining an $\alpha = 0.008$ for each of the t-values reported in Table 19. Even with this α (the level of significance for each comparison), the posttest and pretest attitude scores for the concepts of making fertilizer decisions and applying general knowledge to specific situations were significantly different.

In order to determine the difference in the magnitude of change between the attitude pretest and posttest mean scores for the experimental and control treatment groups, the following null hypothesis was tested:

> Ho_8: There is no significant difference between treatment attitude posttest scores after variations due to attitude pretest scores are removed.

Analysis of covariance with one factor (treatment) and one covariate (overall pretest attitude score) was conducted to test Ho_8. Overall attitude mean scores rather than mean scores for each concept were used to eliminate the chances of experimental-wise error explained earlier. Results of the analysis of covariance using GLM (General Linear Model) procedure are summarized in Table 20. The third F-value reported in Table 20 was used to test the differences between treatment group posttest attitude mean score after adjusting for the covariate (pretest score). The observed F-value was not statistically significant ($P < .05$). Data supported the null hypothesis. The investigator failed to reject null hypothesis number 8 (Ho_8). Two variables for which treatment groups were not similar; namely, semesters of vocational agriculture and semesters of economics were used in the model as covariates. Data

Table 20. Analysis of covariance for the overall posttest attitude scores comparing treatment groups using pretest attitude score as covariate

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Model	2	8.00	4.00	14.70	0.00
Treatment (unadjusted)	1	0.74	0.74	2.74	0.11
Treatment (adjusted for the covariate)	1	0.63	0.63	2.33	0.13
Covariate (pretest response)	1	7.26	7.26	26.67	0.00
Error	24	6.53	0.27		

analyses revealed a small F-value (1.34). This F-value was still not significant beyond .05 level.

In order to compare treatment group scores on the basis of group responses to each of the concepts included in the attitude inventory instrument, posttest responses to each concept were investigated using analysis of covariance method explained earlier. Results of these analyses are summarized in Table 21. Data in Table 21 revealed no significant difference between treatment group posttest attitude means on 5 of the concepts included in the instrument. The only highly significant F-value ($P < .01$) in Table 21 was the value for the concept of making fertilizer decisions. Treatment groups differed significantly when posttest group means were compared.

In summary, inferential analyses of dependent variables indicated

Table 21. Comparison of treatment group posttest responses on each concept in the attitude scale

Subscale concept	Posttest response mean Control (N=12)	Experimental (n=15)	Overall (N=27)	F-value[a]	Prob.
1 Importance of testing	5.81	6.20	6.03	2.50	0.12
2 Making fertilizer decisions	5.89	6.38	6.16	16.03	0.00
3 Safe use of fertilizer materials	6.13	6.47	6.32	2.58	0.12
4 Learning about soil fertility and fertilizers	5.50	5.85	5.69	1.57	0.22
5 Applying general knowledge to specific situations	5.59	5.92	5.77	2.63	0.11
6 Being familiar with sources of information	5.84	6.17	6.02	2.59	0.12
Overall response	5.80	6.13	5.98	2.33	0.13

[a]These F-values were obtained for the effect of treatment in the analysis of covariance after variations due to covariate (pretest) were removed.

that soil fertility and fertilizers knowledge scores were significantly higher for the posttest than the pretest. Furthermore, the experimental treatment group showed a statistically higher ($P < .05$) increase than the control treatment group. Attitude change from pretest to posttest was significant for the experimental group. For the control group, attitude change from pretest to posttest was not statistically significant. No significant difference was found between treatment groups when their overall attitude score differences were compared. When treatment groups were compared on the basis of their responses to the concept of making fertilizer decisions, data favored the experimental group. The direction of change from pretest to posttest was not similar for both groups.

Correlation and Regression Analyses of Variables

The fourth objective of this study was to determine if significant relationships existed among students' personal or situational characteristics, and student performance on the soil fertility knowledge inventory or the soil fertility attitude inventory. In order to accomplish this objective, Pearson-product moment coefficients of correlation was computed between each pair of interval-level variables. Three types of relationships were investigated: (1) relations between independent variables, (2) relations between dependent variables, and (3) relations between independent and dependent variables.

Relation between independent variables

The correlation coefficients calculated for selected student personal and situational variables are presented in Table 22. Data in Table 22 revealed that significant coefficients of correlation existed between three independent variables, namely, semesters of economics, science, and mathematics completed by students. The positive correlations between these variables indicated that they were measuring a similar concept, a kind of "academic preparation". Similarly, three other independent variables were significantly correlated. These were years of FFA membership, semesters of vocational agriculture, and acres on student home farm. These independent variables were measuring a similar concept "orientation to agriculture". A significant correlation was found between grades normally received in school and semesters of mathematics completed. The correlation coefficient of .09 existed for the relationship between the number of semesters of vocational agriculture completed and acres on student's home farm. This value was not statistically significant. No significant correlation was found between grades normally received in school and years of FFA membership, semesters of vocational agriculture completed or semesters of economics and science completed.

Relations between dependent variables

Class means were used in the analyses of relationships among dependent variables. The variables analyzed were: (1) knowledge pretest score, (2) knowledge posttest score, (3) overall attitude pretest score,

Table 22. Correlation analyses of selected students' personal variables

Variable	Description	1	2	3	4	5	6	7	8
1	Years of FFA membership								
2	Semesters of vocational agriculture completed	0.54**							
3	Semesters of economics completed	0.15**	0.15**						
4	Semesters of science completed	0.20**	0.31**	0.10*					
5	Semesters of mathematics completed	0.27**	0.35**	0.09*	0.63**				
6	Acres on student's home farm	0.10*	0.09	0.01	-0.01	0.04			
7	Year in school	0.42**	0.42**	0.38**	0.27**	0.28**	0.04		
8	Grades normally received in school	-0.09	-0.05	0.04	0.09	0.15**	0.01	0.02	

*Significant at .05.

**Significant at .01.

(4) overall attitude posttest score, and (5) period in which the unit was taught. The last variable was considered "procedural"; that is, it was program procedure conducted by vocational agriculture teacher. Results of these analyses are summarized in Table 23. Data in Table 23

Table 23. Correlation analyses of dependent variables

Variable[a]	Y_1	Y_2	Y_3	Y_4	Y_5
Y_1					
Y_2	0.58**				
Y_3	0.62**	0.32			
Y_4	0.53**	0.69**	0.71**		
Y_5	0.46**	0.40*	0.33*	0.31	

[a] Y_1 = Knowledge pretest score.
Y_2 = Knowledge posttest score.
Y_3 = Overall attitude pretest score.
Y_4 = Overall attitude posttest score.
Y_5 = Period in which the unit was taught.

*Significant at .05.

**Significant at .01.

revealed the existence of a nonsignificant correlation coefficient between overall attitude posttest score and period in which the unit was taught. Period in which the unit was taught was highly correlated with knowledge posttest score. The correlation coefficient between knowledge posttest score and overall attitude posttest score was 0.32 and was not significant ($P < .05$). The remaining dependent variables in Table 23, namely, knowledge pretest score, knowledge posttest score, overall attitude pretest score, and overall posttest knowledge score produced highly significant correlation coefficients. An interpretation of data in Table 23 suggested a high correlation between class performance on the pretest and their performance on the posttest administration of the knowledge and attitude inventory instruments.

<u>Relations between independent and dependent variables</u>

Relationships between independent variables and those dependent variables which were affected by the treatment levels were analyzed. First, selected student personal and situational variables were correlated with their scores on the pre- and postexperiment administration of knowledge and attitude inventories. The correlation coefficients for these variables are presented in Table 24.

It was disclosed that only two independent variables were significantly ($P < .05$) correlated with pretest knowledge score. These variables were acres on student's home farm and grades normally received in school. The correlation coefficient for these variables were 0.22 and 0.25, respectively. A significant positive correlation was found between grades normally received in school and posttest knowledge score. Posttest knowledge score was observed to be negatively correlated with semesters of vocational agriculture, semesters of economics, and student's year in school.

Table 24. Coefficients of correlation between knowledge score, attitude score and student personal variables

Independent variable	Knowledge score		Attitude score	
	Pretest	Posttest	Pretest	Posttest
1. Years of FFA membership	-0.01	-0.09	0.03	-0.08
2. Semesters of vocational agriculture completed	0.06	-0.13*	0.05	-0.03
3. Semesters of economics completed	-0.05	-0.30*	-0.01	-0.22**
4. Semesters of science completed	0.05	-0.06	0.00	-0.01
5. Semesters of mathematics completed	0.05	0.00	-0.04	0.01
6. Acres on student's home farm	0.22**	0.03	0.03	0.12*
7. Year in school	0.00	-0.24**	0.08	-0.18**
8. Grades normally received in school	0.25*	0.21**	0.12*	0.11*

*Significant at .05.

**Significant at .01.

Pretest and posttest attitude scores and grades normally received in school had significant coefficients of correlation. Posttest attitude score was negatively correlated with semesters of economics completed and student's year in school. A significant and positive coefficient of correlation was observed between posttest attitude score and acres on student's home farm. Posttest attitude score and grades normally received in school also had a positive and significant ($P < .05$) coefficient of correlation.

Data in Table 25 present an analysis of relationships between teacher, school, and dependent variables. It was observed that no

Table 25. Coefficients of correlation between class performance, teacher, and school variables

Teacher or school variable	Posttest knowledge score	Posttest attitude score
1. School enrollment	-0.11	0.15
2. Teacher tenure	0.13	0.23
3. Vocational agriculture departmental enrollment	0.13	0.18
4. Class size	-0.01	0.14
5. Number of classes taught daily	0.01	0.12
6. Period in which the unit was taught	0.39*	0.29
7. Teacher's knowledge of soil fertility	0.14	0.18
8. Months of business experience	0.07	0.15

*Significant at .05.

significant correlation existed between posttest knowledge score or posttest attitude score and the following independent variables: (1) school enrollment, (2) teacher tenure, (3) vocational agriculture departmental enrollment, (4) class size, (5) number of day-classes taught, (6) teacher's knowledge of soil fertility, and (7) months of business experience.

The only significant ($P < .05$) coefficient was observed between posttest knowledge score and period in which the unit was taught.

Those independent variables which had significant correlation coefficients when compared with posttest knowledge score were analyzed through the use of stepwise regression procedure. Posttest knowledge score was used as the Y variable. Results of this analysis are presented in Table 26. Data in Table 26 revealed that only four variables had

Table 26. Stepwise regression analysis of posttest knowledge scores

Step	Variable entered	B[a]	Multiple R	R^2	F-value
1	Pretest knowledge score	0.70	0.57	0.33	150.60
2	Semesters of economics	-3.37	0.63	0.39	102.17
3	Treatment group	7.54	0.66	0.44	80.22
4	Semesters of Vo. Ag.	-1.85	0.67	0.45	62.15
	Constant = 43.68				

[a]Regression coefficient in the final equation.

significant F-values allowing them to enter the prediction equation. These variables were pretest knowledge score, semesters of economics, treatment group, and semesters of vocational agriculture completed. These variables accounted for 45 percent of the variation in the posttest scores ($R^2 = 0.45$).

Stepwise regression analysis was also performed on posttest attitude scores. Results of this analysis are presented in Table 27. Data

Table 27. Stepwise regression analysis of posttest attitude scores

Step	Variable entered	B	Multiple R	R^2	F-value
1	Pretest attitude score	0.39	0.42	0.17	65.74
2	Treatment group	0.37	0.48	0.23	47.36
3	Semesters of economics	-0.12	0.52	0.27	37.59
	Constant = 3.62				

in Table 27 revealed that three variables had significant F-values allowing them to be entered in the prediction equation. They were pretest attitude score, treatment group, and semesters of economics completed. These variables accounted for only 27 percent (R^2 = 0.27) of variation in the posttest attitude scores.

In summary, correlation analyses revealed several significant coefficients of correlation between independent variables. Most of the significant correlations were between variables which seemed to measure an underlying concept. For example, semesters of science, mathematics, and economics were all measured academic background.

Dependent variables revealed significant relationships in eight of 10 correlation coefficients. All were positive correlations. Several of the independent variables explained significant amount of variation in the criterion variables; nevertheless, stepwise regression reveals that 45 percent of variation in the posttest scores could be explained by four independent variables.

Analyses of the Teachers' Rating of the Instructional Unit

The fifth and final objective of this study was to identify teachers' perceptions of the instructional unit. In order to accomplish the objective, a two-part evaluation instrument with a total of 22 items was completed by teachers in the experimental group at the conclusion of the experiment. For the first part of the instrument, teachers were asked to indicate their feelings toward the quality of the unit in terms of eleven bipolar adjectives on a semantic differential scale (see Appendix C). For computational purposes, digits were assigned to each scale as follows:

useless :___:___:___:___:___:___:___: useful
1 2 3 4 5 6 7

Mean score for each bipolar scale was then computed and is graphically presented in Figure 5. Inspection of scale response means revealed that all means were above the midpoint of the scale (4.0). With the exception of the "simplicity" characteristic, all scale response means were directed towards the positive side (above 5.0). It was observed that "accuracy" and "worth" characteristics had the highest computed scale response mean. A response mean of 6.13 was computed for these two characteristics. The "simplicity" characteristic on the other hand, had the lowest response mean of 4.20. The next lowest response mean was observed for the characteristic labeled "readability". Overall, more than 72 percent of the response means computed had a value greater than 5.50.

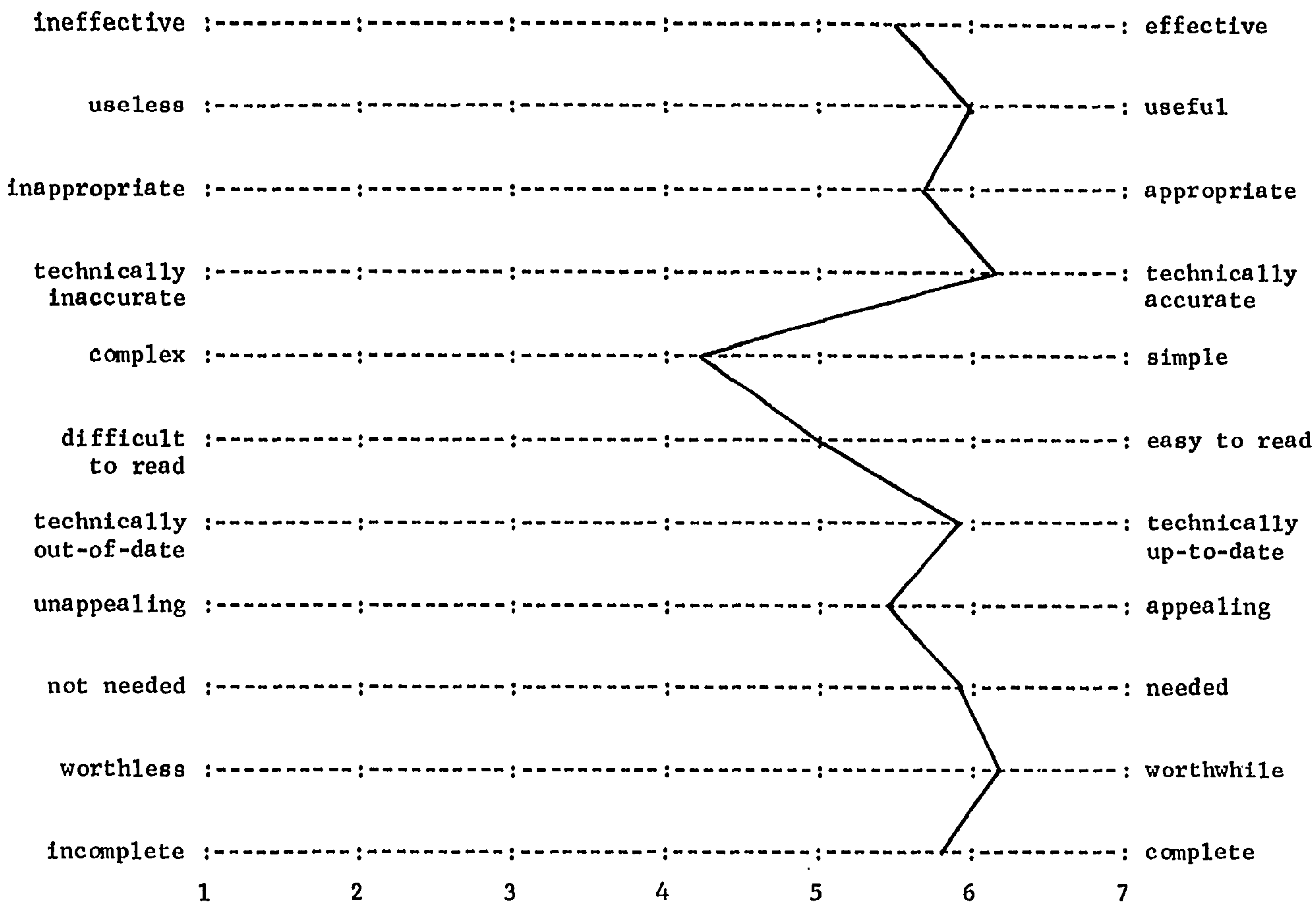

Figure 5. Teacher evaluation of the instructional unit (N=15)

For the second part of the instrument, instructors were asked to evaluate the format and components of the instructional unit using a 9-point Likert scale (see Appendix C). Means, standard deviations, and ranks (in terms of the highest response mean) are presented in Table 28. Data in Table 28 revealed that highest response means belonged to items concerning the value of: (1) problem area outlines in

Table 28. Instructor mean, standard deviation and rank of unit components

Unit component	Mean[a] (N=15)	S.D.	Rank[b]
Problem area	6.40	1.05	8
Study questions	6.27	1.16	10
Learner needs	6.00	1.07	11
Interest approach	6.60	1.40	7
Learning activities	7.53	1.12	3
Conclusions	6.73	1.16	6
Evaluation criteria	6.80	1.47	5
Optional learning activities	6.33	1.50	9
Decreasing preparation time	7.67	0.72	1
Development of future units	7.00	1.60	4
Distribution to other teachers	7.66	0.98	2

[a]Values were: 1 = no value, 5 = some value, 9 = utmost value.

[b]Mean responses from high to low were ranked by the researcher comparing mean values for each item.

decreasing preparation time ($\bar{X} = 7.67$), (2) distributing to other vocational agriculture teachers in Iowa ($\bar{X} = 7.66$), (3) learning activities in providing realistic experiences for students to acquire knowledge and understanding of the problem area ($\bar{X} = 7.53$), and (4) developing instructional units in other subject matter areas for future use ($\bar{X} = 7.0$). The item with highest response mean (decreasing preparation time) also had the lowest standard deviation indicating uniform response among teachers. With the exception of the item concerning the value of learner needs, other items had response means greater than 6.0. The mean value for the item related to learner need was 6.0 with a standard deviation of 1.16.

Among the components of the unit, learning activities had the highest response mean ($\bar{X} = 7.53$). This component was considered to be of greatest value to experimental group teachers. Other components, namely, problem area, study questions, interest approach, conclusions, evaluation criteria, and optional learning activities also had mean response values greater than 6.20.

Additional comments received from the teachers who used the instructional unit both verbally and in writing were mostly favorable. Excerpts from some comments taken from returned responses are presented as follows:

> I definitely improved my teaching of soil fertility--mostly an improvement in efficiency (teacher with 34 years of teaching experience).

> This unit was set up fairly well. The main problem I saw with it was that it might have been too advanced for my sophomore class. I do think it is more appropriate for my other classes (first-year teacher).

> Very good unit on the subject.
>
> Materials for some lab activities were not available at our school.
>
> Run off activities and easy to prepare interest approaches, cut preparation time and allowed more time to really teach and do SOE and FFA activities.

Some teachers suggested that the microcomputer program included in the unit be saved on a diskette. These teachers had difficulty adapting the program on the school computer system.

In summary, interpretation of data indicated that teachers considered the learning activities component of the unit as the most valuable component. Learner needs, on the other hand, had the lowest response mean. The value of problem area outlines in reducing preparation time received the highest mean value. The next highest mean response was obtained for the value of distributing the unit to other vocational agriculture teachers in Iowa.

Summary of Major Findings

Based on the analyses of data used in this investigation, the following statements summarize the major findings:

1. Inferential analyses (Chi-square or t-test) of the student, teacher, and school characteristics revealed that random assignment of classes to treatment groups was successful. Only student grade level, semesters of vocational agriculture completed, and semesters of economics or business completed were significantly associated with the treatment group to which teachers and their classes were assigned. All other student, teacher,

and school variables failed to reflect any significant association with treatment group.

2. Investigation of the two principal instruments (knowledge and attitude inventories) revealed high coefficients of reliability. Other analytic procedures pointed out that the two instruments and scoring procedure used were statistically acceptable measures.
3. Both experimental and control group classes scored significantly higher on the knowledge posttest than on the pretest.
4. The experimental treatment group classes scored significantly higher on the posttest administration of the knowledge inventory instrument than the control group classes after variations due to pretest scores were removed.
5. Experimental group classes had significantly less variable posttest knowledge scores than did control group classes.
6. Classes in the experimental treatment group scored significantly higher on the attitude inventory posttest than on the pretest.
7. For the control group classes, no significant difference was found between overall attitude posttest scores and pretest scores.
8. The direction of change from pretest attitude score to posttest attitude score was not the same for the two treatment groups.
9. No significant difference was found between treatment overall attitude scores after variations due to pretest scores were removed.

10. Experimental group attitude scores on the concept of making fertilizer decisions were significantly higher than control group attitude scores after variations due to pretest scores were removed.
11. Student scores on the pretest administration of knowledge or attitude inventory instrument were significantly correlated to scores on the posttest administration of those instruments.
12. A significant and positive correlation existed between grades normally received in school and semesters of mathematics completed.
13. A significant and positive correlation existed between grades normally received in school and student posttest knowledge scores.
14. Pretest score, semesters of economics completed, treatment group, and semesters of vocational agriculture were significant predictors of student posttest knowledge score.
15. Teachers in the experimental treatment group spend more time teaching soil fertility and fertilizers than did teachers in the control treatment group. The difference, however, was not statistically significant.
16. Teachers in the experimental group responded favorably to the value and quality of the soil fertility and fertilizers instructional unit.
17. Experimental group teachers placed a high value on the instructional unit in terms of reducing teacher preparation time.

18. Teachers indicated that the learning activities were the most valuable component of the instructional unit.

DISCUSSION

The overall purpose of this investigation was to evaluate the effectiveness of an instructional unit on soil fertility and fertilizers which was developed by the investigator for use by vocational agriculture teachers in Iowa. Data collected from selected vocational agriculture teachers and their students were analyzed to accomplish that objective.

The investigation was experimental in nature. Experimental studies are believed to be the most rigorous means of establishing a true cause and effect relationship available to educational researchers (23). Furthermore, the review of literature revealed that instructional materials should be evaluated through the use of carefully designed experiments to determine their effectiveness in increasing student knowledge and skill and bringing about behavioral changes desired by teachers. Based on this background information, a design known as pretest-posttest control group design, was selected from the widely-used description of research designs provided by Campbell and Stanley (8). This design is somewhat stronger than others in that it incorporates both randomization and control groups therefore controlling for most of the threats in a study's internal and external validity. The investigator also felt that the data collected through the use of such a design could be more easily interpreted. The only real defect in this design is that if the pretest is reactive, its influence may confound the learner response to the treatment condition. The researcher, however, did not perceive any likelihood that reactive effects would be yielded by the use of a soil fertility pretest.

Participating teachers and their classes were not randomly selected. Rather, they were selected among a list of seventy-two teachers nominated by project staff. Early in the experiment, project staff were asked to nominate those teachers whom they felt would be able to provide an adequate test of the instructional unit. The assignment of teachers to control and experimental groups, however, was accomplished at random, thus controlling for selection which is a threat to internal validity of a design. Nevertheless, because of the nonrandom selection of teachers, generalizations of findings may not and was not extended to all Iowa vocational agriculture programs on a statistical basis. The underlying assumption of this study was that programs used in the investigation were reflective of current vocational agriculture programs in Iowa at the secondary school level. According to Hinkle (17, p. 201):

> Nonrandom samples can be used in research. If assignment to treatments is random, inferences based on statistical results can be made to the individuals included. Such inferences may be extended to other populations, but only on a logical, not a statistical, basis.

The findings of this investigation were interpreted based on the above assumption and the limitation that nonrandom selection was a threat to external validity.

Another threat to internal validity of a design is known as "experimental mortality" (39, p. 99). This investigation started with a sample size of 38 classes with equal numbers randomly assigned to the experimental and control treatment groups. Usable data, however, were collected from 15 classes in the experimental treatment group and 12 classes in the control treatment group.

Attempts were made by the investigator to identify factors which contributed to this mortality rate and find out if the loss of respondents from the comparison groups was random. Among the factors identified were late arrival of materials, failure to get informed consent signature, and change in vocational agriculture program offering. It was observed that unfavorable weather conditions during the winter of 1982 (the time during which the experiment was conducted) caused many school cancellations in Iowa which in turn required adjustments in program offerings by some vocational agriculture teachers in the experiment. Although the investigator was convinced that loss of respondents from the comparison groups was random, data were analyzed on the basis of an unbalanced design to adjust for the effect of mortality rate.

Except for the two limitations mentioned, the investigator felt that the design was adequate in providing conditions needed to accomplish the overall purpose of the experiment. By using a control group which presumably had all the characteristics of the experimental group, except the treatment itself, the investigator was able to reduce threats due to history and instrumentation. Administering a pretest to classes in both groups enabled the researcher to measure and control for initial differences that might have existed between groups.

When unequal groups are used in a pretest-posttest control group design, one should establish as much similarity as possible between the two groups. The investigator analyzed all student, teacher, and school characteristics which were not influenced by the use of instrunctional unit itself to identify similarities and differences between the two groups. These analyses were used in determining to what degree random assignment of classes to treatment groups was successful.

Analyses of student personal and situational data revealed that treatment groups were homogeneous with respect to student place of residence, grades normally received in school, plans after graduation, size of student's home farm, years of FFA membership, and semesters of science, or mathematics completed. They were not homogeneous with regard to the student grade level, semesters of vocational agriculture completed, and semesters of economics completed. In the main, the investigator concluded that random assignment of classes to treatment groups was successful with regard to these student variables. Despite this conclusion, it was decided that student grade level, semesters of vocational agriculture completed, and semesters of mathematics completed might have an impact on student performance on a soil fertility test. These variables were used in the inferential analyses comparing treatment groups.

Findings related to student personal variables were compared with those of other investigators in agricultural education. For example, it was found that the majority of students (74.8%) lived on a farm. Another 9.2 percent lived in a rural area, but not on a farm. These findings were similar to those reported by Briers (6). He found that 76 percent of the students in his random sample were from the farm, 9.8 percent lived in a rural area, and 13.7 percent lived in a town. This similarity supported the underlying assumption mentioned earlier. Although the selection of classes was not accomplished at random, student characteristics in this study were similar to those randomly selected by other investigators. Furthermore, the researcher concluded that the majority of vocational agriculture students in the study were farm oriented. The implication of this finding implies, despite the attempts made by several educators, that vocational agriculture programs are still not absorbing as many urban oriented students as possible. Further research is needed to address this issue.

The analyses of teacher and school variables detected no differences between treatment groups. The investigator concluded that the random assignment of teachers and/or classes to treatment groups had successfully affected homogeneity between both groups for selected school and teacher variables measured.

The two main instruments which were used to collect information on the dependent variables, namely, soil fertility and fertilizers knowledge inventory and soil fertility attitude inventory, appeared to be appropriate. The knowledge inventory instrument was an objective test of 40 multiple-choice items. The test was developed by the investigator and administered as a pretest and a posttest, with the items randomly arranged for each administration.

In order to reduce the chance of being biased, problem areas and study questions were used in the development of the inventory. The investigator was satisfied with this approach because both the experimental and control group teachers had access to and presumably used the same problem areas and study questions in their instruction. Furthermore, the instrument was reviewed and suggestions for revision were made by the staff members in the Department of Agricultural Education at Iowa State University who had not at that point in time seen the instructional unit. These conditions satisfied the investigator's curiosity about the degree of bias which might have been built into the instrument.

Results of reliability and item analysis of the knowledge inventory instrument proved to be most favorable in this investigation. The reliability coefficient (KR-20 reliability estimate) from the pretest and posttest forms of the instrument were .85 and .92, respectively. The investigator believed these estimates were good for a short (40) item teacher-made test. The item difficulty means were also reasonable for a criterion-referenced test. The investigator was not interested in comparing the individuals with a norm-group. Therefore, mean item difficulties of .59 and .74 (for pretest and posttest, respectively) were satisfactory. Based on the results of item and reliability analyses, the investigator concluded that this instrument was a reliable instrument in assessing student knowledge of soil fertility and fertilizers. Those researchers who are interested in developing standardized tests on agricultural subjects might find this instrument useful in their work.

Student attitudes toward selected concepts in soil fertility and fertilizers were examined through the use of a semantic differential technique (31). The investigator selected this technique because of its appropriateness in measuring student responses toward soil fertility concepts. Furthermore, it was learned through the review of literature (24, 27, 31) that this technique is especially useful when dealing with high school-aged students. Granted, to the best of this writer's knowledge, educators have not yet come up with a clear acceptance of a definition of attitudes, let alone developing an instrument which could precisely measure them. The investigator, however, assumed that by using this technique as opposed to a Likert-type scale with numerical values, students would provide more realistic and meaningful responses.

Results of reliability and item analyses revealed that several subscales on the 30-item scale used to collect student data had low reliability estimates (coefficient alpha below .80). Those estimates were not acceptable to the investigator. The decision was made to factor analyze the items on the attitude instrument. This procedure resulted in the discovery of several low factor-loading items. After deleting these items, a modified scale was used in the analyses of data. It is this investigator's belief that factor analysis is a powerful statistical tool and educational researchers, whether conducting survey research or experimental research, are well-advised to use this technique in their investigations. Further research is needed to evaluate the usefulness of semantic differential technique in agricultural education.

In the main, after modifying the attitude inventory instrument, the investigator concluded that both dependent variable data gathering instruments were statistically acceptable. All dependent variables measured by these instruments were then analyzed to determine relationships among variables and causes and effects.

Analyses of data revealed that both experimental group and control group classes scored significantly higher on the posttest administration of the knowledge inventory than they did on the pretest. This finding led the researcher to conclude that the instruction provided during the time in which the experiment was conducted had been successful in increasing student knowledge of soil fertility and fertilizers. These findings were compared with the results of other studies in which pretest-posttest control group designs were used. Not surprisingly, similar findings were reported by other educational researchers such as Kahler (22), Briers (6), and Zurbrick (48). Learning that occurred during the period between pretest and posttest was believed to have been the result of efforts by teachers and their students in a teaching-learning environment. These efforts, the investigator believed, enhanced student understanding of soil fertility and fertilizers as measured by the knowledge inventory instrument.

When groups were compared on the basis of class performance on the pretest administration of the knowledge inventory instrument, it was found that experimental and control group classes scores were significantly different. This finding led the researcher to conclude that classes in the two treatment groups were not similar on the basis of their previous knowledge of soil fertility and fertilizers. In fact, classes in the experimental treatment group scored significantly higher on the pretest knowledge test than did classes in the control treatment group. This finding has significant implications in choosing a design when initial student knowledge of the subject matter is in doubt. Had the investigator not chosen a pretest-posttest control group design, he might not have been able to account for the variation due to students' prior knowledge of the subject matter. Based on this finding, future researchers are well-advised to use a pretest-posttest control group design when the initial differences between groups are in doubt and researchers are certain that students are not reactive to the pretest.

Findings of significant difference between treatment groups' pretest scores along with other dissimilarities required careful selection of inferential statistical techniques for comparison of treatment groups. The investigator used analysis of covariance to make these comparisons. The advantage of this technique is that it gives the researcher the ability to compare posttest scores after variations due to pretest scores (or any other covariate) have been removed.

Experimental and treatment groups were compared using analysis of covariance. It was found that experimental treatment group scores on the posttest were significantly higher than those of the control treatment group after variations due to pretest scores had been removed. Since treatment groups were found to be different on the number of semesters of vocational agriculture and economics completed, the researcher decided to add these two variables in the covariate analysis. Results of this test again favored the experimental treatment group. This finding led the researcher to conclude that for those classes in which the instructor used the soil fertility unit, knowledge of soil fertility improved significantly more than classes in which traditional materials were being used (to teach this subject). This conclusion, however, should be viewed in the framework of this study only. Other Iowa studies have not yielded the same results. The only study which yielded a significant difference in knowledge was a study of a Supervised Occupational

Experience (SOE) packet completed by Briers (6) in 1978. Even in that study, Briers had to choose a significant level of .10 (α = .10) to show any difference. One factor which could be used to explain the dissimilarities between this finding and findings of other researchers could be the length of time in which the unit was taught. Data for this study revealed that on the average, experimental group teachers spent about 27 hours teaching the unit, whereas teachers in the control treatment group spent about 20 hours teaching the unit. The difference, however, was not statistically significant. Although the length of time that the unit was taught did not differ significantly, the experimental group teachers spent more time on their unit than did their counterparts in the control group. The investigator believes that this fact has an implication in agricultural education. That is, teachers who have access to quality instructional materials in soil fertility and fertilizers would be apt to spend more time teaching this subject.

The overall attitude scores changed significantly from pretest to the posttest for the experimental treatment group. For the classes in the control treatment group, this change, however, was not significant. This finding led the researcher to conclude that classes in the experimental treatment group changed their attitudes toward selected concepts in soil fertility and fertilizers (as measured on the attitude inventory scale) during the experiment. Further analyses of data revealed that the change was only significant for the following concepts: (1) making fertilizer decisions, (2) learning about soil fertility and fertilizers, (3) applying general knowledge to specific situations, and (4) being familiar with sources of information. Attitudes toward importance of testing soils and safe use of fertilizer materials did not change significantly during the experiment.

The investigator believes two factors might have had an impact in such finding. First, unlike beliefs that might change in short time periods, attitudes require longer time to change. The second factor is related to the development of the instructional unit. As mentioned earlier (see Methods and Procedures Chapter) in the development of the unit, learning activities were designed that would not only enhance student knowledge of the subject matter, but also deal with learner needs and affective domain objectives. Six concepts which were used on the attitude inventory instrument were those that the investigator felt could be dealt with in a soil fertility course. Furthermore, these concepts were emphasized throughout the unit. The finding of change in attitudes toward four of the six original concepts by the experimental group classes came as no surprise to the researcher. When treatment groups were compared using covariate analysis, it was observed that for the concept of making fertilizer decisions, a significant difference existed between comparison groups. Findings favored the experimental group.

These findings could further be explained by the fact that the soil fertility and fertilizers unit was developed using a problem-solving format (see Methods and Procedure Chapter). Instructors who used the unit had to address the subject matter in a problem-solving (decision-making) approach. This approach could have resulted in favorable attitude toward the concept of making fertilizer decisions by the experimental group classes. Deciding about brands and kinds of fertilizers requires a systematic decision-making process which the investigator believes was acquired by the experimental group classes because they were exposed to this approach.

Another finding which could be linked to the use of problem-solving approach in the unit was the fact that treatment group variances for the knowledge scores were significantly different. Both groups started with essentially the same variation in scores. Pretest score standard deviation was 7.82 for the experimental group and 7.76 for the control group. These values changed to 9.21 and 15.36 during the postadministration of knowledge inventory for the experimental and control groups, respectively. Data revealed that variations in the scores increased significantly higher for the control than the experimental treatment group. This finding led the investigator to conclude that scores for the experimental group classes were more uniform than those for the control group. The investigator believes that because all classes in the experimental treatment group were exposed to a uniform problem-solving instruction approach, more uniformity might have been observed in their scores when compared with classes in the control group.

During the comparison of treatment groups on the basis of their overall posttest attitude scores, the investigator was faced with a rather technical problem which he felt had an impact on the analyses of data collected from unequivalent groups. As mentioned earlier, the statistical technique chosen for comparing treatment groups was analysis of covariance. The researcher had to select between two systems of computer programs available to many researchers: The Statistical Package for the Social Sciences (SPSS) (29) and the Statistical Analysis System (SAS) (4). For analysis of covariance, either SPSS Subprogram ANOVA or SAS procedure GLM could be used. The investigator, because of his personal interest in matters that deal with statistics and "model meddling," decided to use both and compare the outcomes. Surprisingly, SPSS Subprogram ANOVA detected a significant (P = .05) F-value for the effect of treatment adjusting for the covariate, whereas SAS procedure GLM produced an F-value which was significant only beyond .13 (P = .13). Educational researchers who might be working with unbalanced designs would be well-advised to use the SAS procedure GLM rather than SPSS Subprogram ANOVA.

In the main, the investigator concluded that use of the instructional unit had significantly increased class knowledge of soil fertility and fertilizers (as measured by the knowledge inventory) and had a significant impact on attitudes toward the concept of fertilizer decision-making.

In an attempt to explain the amount of variations in knowledge and attitude scores, the researcher examined relationships between several student, teacher, and school variables measured and student performance through the use of correlation and regression techniques.

Observed positive correlations between semesters of economics, science, and mathematics completed led the researcher to conclude that these variables were measuring a similar concept--a kind of "academic preparation". Similarly, because years of FFA membership, semesters of vocational agriculture, and acres on student's home farm were postively correlated, the researcher concluded that these variables were measuring a similar concept--a kind of "orientation to agriculture". An observed positive correlation between semesters of vocational agriculture and acres on student's home farm supported the previous finding that the majority of vocational agriculture students were from farms. Interestingly, semesters of mathematics completed was significantly and positively correlated with grades normally received in school indicating that students with higher letter grades tended to have completed more semesters of mathematics. Grades normally received in school was also positively correlated with student pretest knowledge score indicating that students with higher letter grades tended to score higher on the pretest administration of knowledge inventory. Finding of correlation between farm size and pretest score led the investigator to conclude that students whose parents had a larger farm tended to have higher pretest knowledge score.

Some of these findings were similar to the findings reported by other researchers in agricultural education. Kahler (22) reported significant correlation between students' IQ scores and their performance on an agricultural knowledge test. The investigator believes that in cases where obtaining IQ scores might be difficult, researchers could simply ask students to report the letter grades they normally received in school. This technique was used by Briers (6).

Findings of significant and positive coefficients of correlation between pretest and posttest scores led the researcher to conclude that students with higher scores on the pretest administration of knowledge and attitude inventory instruments also tended to score higher on the posttest administration of those instruments. These findings further supported the proposition of using pretest scores as covariates in the comparison of treatment groups.

Attempts were made to use student personal variables in predicting their posttest scores. Equations produced as a result of regression analyses explained less than 50 percent of variation associated with the posttest scores. These analyses resulted in identifying significant predictor variables. More variation in the posttest knowledge scores was explained by these variables than posttest attitude scores (R^2 was .45 and .27 for posttest knowledge and attitude scores, respectively). Students' pretest scores, semesters of economics, treatment group, and semesters of vocational agriculture were the predictor variables identified as a result of the regression analysis. Finding less degree of predictability for attitude scores was not surprising as the researcher contends that attitudes are not easy to measure by paper and pencil instruments.

In the main, teacher evaluation of the instructional unit revealed that they responded favorably to the quality and value of the instructional unit. The characteristics receiving highest ratings by the teachers were those related to the accuracy of information in the unit and worth of the unit. The researcher concluded that teachers perceived the unit to be technically accurate and useful. Simplicity was the lowest rated characteristic indicating teachers were concerned about the complexity of the unit. This observation was in agreement with the observed high mean responses to the technical accuracy of the unit in that for the unit to be technically accurate, a certain degree of complexity might have been built into the unit. Furthermore, when experimental teachers' general knowledge of soil fertility (as reported on a 1 to 5 scale) were examined, it was observed that these teachers had an average rating of 3.75. The investigator believes more inservice workshops are needed to help teachers become familiar with current developments in the courses of soil fertility and fertilizers. Analysis of teachers' responses to the value of the individual components of the unit revealed that the majority of the items had a response means above the scale midpoint. The researcher concluded that all components were valuable to the experimental group teachers as they taught the unit.

The most valued aspects of the instructional unit were problem area outlines and their contribution to decreasing preparation time. This finding was similar to the findings of other instructional material evaluation studies. In almost all of the studies reviewed, teachers considered the instructional materials being tested helpful in reducing preparation time. It was also observed that the learning activities component of the unit received a high rating by teachers. Interestingly, experimental group teachers uniformly rated this component of high value. This finding was also common in other studies reviewed.

Comments received from most instructors were generally positive about the instructional unit. Individuals involved in future instructional materials development efforts may find the format of this unit of value in their work. Items related to the development of future units in other subject-matter areas and distribution of this unit to other teachers in the state received a high response value.

In summary, the investigator made the following conclusions with respect to the specific objectives of the study. The first objective was to determine if the use of this instructional unit would significantly increase students' knowledge of soil fertility and fertilizers. Finding of significant difference between pretest and posttest knowledge scores led to the conclusion that the use of this unit did, in fact, increase student understanding of soil fertility and fertilizers. The investigator also drew the same conclusion for traditional materials and methods used by teachers in the control treatment group.

The second objective was to determine effects of using this unit on student achievement as compared with instructional materials traditionally used by vocational agriculture teachers. An observed significant difference between treatments' posttest scores after variations due to pretest were adjusted led the researcher to conclude that the use of this unit was more effective in increasing student knowledge of soil fertility than were the traditional materials.

The third objective was related to changes in student attitudes as a result of using the materials organized in the unit. The investigator concluded that student attitudes toward selected concepts in soil fertility (as measured by the attitude inventory) did, in fact, change in a positive direction. When these changes were compared to those of the classes in the control treatment group, the investigator failed to detect any difference in the overall attitude scores. Student attitude scores related to the concept of fertilizer decision-making was significantly different when treatment groups were compared. The investigator concluded that with respect to this concept, the unit was more effective than the traditional materials used. He maintained that this effectiveness was due to the fact that problem-solving (decision-making) approach was used as the overall format of the unit.

The fourth objective of the investigator was to determine if significant relationship existed among students' personal or situation characteristics, and their performance on soil fertility and fertilizers knowledge or attitude inventory. The researcher was able to identify several significant coefficients of correlation indicating relationships between students' personal characteristics and their performance on the soil fertility knowledge or attitude inventory. Among the relationships found (see Table 24 in Findings Chapter) were relationship between: acres on student's home farm and knowledge pretest score, grades normally received and knowledge pretest or posttest score, semesters of vocational agriculture and posttest knowledge score, and semesters of economics and posttest knowledge score. Pretest attitude score, on the other hand, was only correlated to grades normally received in school. Relationships were observed between semesters of economics completed, acres on student's home farm, year in school, grades normally received in school, and posttest attitude score. Correlation coefficients for these variables were both positive and negative. The conclusion drawn from these findings was that there are relationships among some students' personal characteristics and their performance on the knowledge and attitude inventory.

The fifth and final objective of this study was to identify teachers' opinions on such items as scope of the unit, accuracy of information, format of materials, etc. Based on the analysis of evaluation data collected from teachers who used the unit, the investigator concluded that teachers considered this unit a valuable unit in their work. Furthermore, it was concluded that teachers considred the problem area components of the unit as the most valuable part of the unit.

All these conclusions should be viewed within the framework of this study and the nonrandom sample of classes from which the data were collected. They should not be statistically inferred to a general population other than the selected teachers.

SUMMARY

The central purpose of this study was to evaluate the effectiveness of an instructional unit on soil fertility and fertilizers which was developed by the investigator for use by vocational agriculture teachers in Iowa. More specifically, this study was designed to: (1) determine if the use of this unit would significantly increase students' knowledge of soil fertility and fertilizers, (2) determine effects of using this unit on student achievement as compared with instructional materials traditionally used by vocational agriculture teachers, (3) identify changes in student attitudes as a result of using these materials, (4) determine if significant relationships existed among students' personal or situational characteristics, and student performance on soil fertility knowledge inventory or soil fertility attitude inventory, and (5) identify teachers' opinions on such items as scope of unit, accuracy of information, format of materials, etc.

The research procedure was experimental, with a pretest-posttest control group design. The independent variable manipulated by the researcher was the degree to which teachers and students had access to and used an instructional unit on soil fertility and fertilizers. Two levels of the independent variables were used in the study. The experimental group included those teachers and their students who received and used the instructional unit. The control group consisted of teachers and their students who did not have access to the instructional unit.

Teachers in the experimental group were provided with the

instructional unit along with sufficient copies of a student text, Field Crop Nutrition. They were asked to teach the unit as it was outlined and follow the learning activities provided in the unit. Control group teachers were provided with a list of problem areas and study questions outlined in the unit. They were asked to use whatever approach they ordinarily used in teaching soil fertility and fertilizers to their students. These teachers were not allowed access to the instructional unit.

Teachers were selected from a list of all Iowa vocational agriculture teachers and randomly assigned to treatment groups. Participating teachers were not randomly selected as the researcher was less concerned with the ability to generalize findings to other populations and more concerned about an appropriate test of the instructional approach suggested in the unit. Usable data were gathered from 312 students in 27 Iowa vocational agriculture classes. Fifteen classes with the total enrollment of 152 students were in the experimental treatment group, whereas, twelve classes with the total enrollment of 160 students were in the control treatment group.

Five instruments were developed to collect data from teachers and their students: (1) an inventory to measure student knowledge of soil fertility and fertilizers, (2) a 30-item semantic differential scale to quantify students' attitudes toward selected concepts in soil fertility and fertilizers, (3) a questionnaire to elicit personal, educational, and situational data from students, (4) a questionnaire to gather personal and situational information from vocational agriculture teachers, and (5) an evaluation instrument to assess teachers ratings of the instructional unit.

Data were analyzed using classes as the unit of analysis and the following conclusions were drawn.

Knowledge of soil fertility and fertilizers increased significantly in both treatment group classes during the experiment.

Use of the instructional unit produced greater increases in student knowledge of soil fertility and fertilizers.

Attitudes toward selected concepts in soil fertility and fertilizers changed significantly in classes where the instructor taught from the unit.

Use of the instructional unit produced greater change in attitudes toward the concept of fertilizer decision-making than did the use of traditional materials.

Classes in which the unit was used had less variable posttest knowledge scores than did classes in which the traditional materials were used.

The direction of change in attitudes toward selected concepts of soil fertility from pretest to posttest was not the same in both groups.

Students with higher pretest knowledge or attitude scores also had higher posttest scores.

Students with a higher letter grade in school also scored high on the posttest knowledge or attitude inventory.

Teachers considered the instructional unit worthwhile and technically accurate.

Teachers placed a high value on the learning activities component of the unit.

The use of instructional unit was perceived of most value in terms of reducing teacher preparation time.

Teachers considered development of similar units in other subject matter areas valuable.

The following recommendations, based on the findings of this study, warrant consideration by those engaged in development, distribution, and evaluation of instructional materials and future educational researchers.

The instructional unit in soil fertility and fertilizers should be distributed to other vocational agriculture teachers to help them in their instruction of this subject.

Inservice education on the intended use of this instructional unit and similar units should be given to vocational agriculture teachers. Attention should be given to describing the intent and importance of including learner needs in these units.

Individuals engaged in developing instructional materials should try to incorporate a wide variety of materials and techniques into the format of the materials being developed.

Problem-solving format appears to be an appropriate technique upon which to develop instructional materials in agriculturally-related subject matter areas.

The two main instruments used in this study, namely, soil fertility and fertilizers knowledge inventory, and soil fertility and fertilizers attitude inventory may serve as valid and reliable instruments for future researchers.

Other instructional materials should be evaluated to determine their effects on student knowledge, attitudes, and abilities before dissemination to teachers.

Whenever feasible, evaluation of instructional materials should be conducted through the use of carefully planned experimental designs.

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APPENDIX A: CORRESPONDENCE

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September 21, 1981

I hope that your school year has gotten off to a smooth start and that you have set some high goals for your program for the year. We here at ISU are beginning to get settled after the transition from a quarter to the semester system. Many courses have undergone drastic revisions in the process, but students seem to be adjusting rather well.

The purpose for this letter is to solicit your participation in a field test of curriculum materials developed by Project 2000 staff members. We are asking a number of vocational agriculture teachers throughout the state to use materials in the area of Soybean Production, Soil Fertility and Fertilizers, and Agricultural Business Management as a part of this field test. These materials consist of learning activities and instructional materials dealing with problems in each of those areas of study. Materials will be provided to each school without charge.

Participation on your part would involve the use of these materials as they are written and administration of a pre-post test to determine their effects on student achievement. Our goal is to ultimately determine the effectiveness of these materials on teaching vocational agriculture in Iowa. Other schools have been selected to serve as a control group which will utilize traditional instructional materials in these areas. Pre-test and post-test scores for both groups will be compared to determine the effectiveness of Project 2000 materials in relation to traditional materials presently being used.

Evaluation of instructional materials is an important aspect of curriculum material development. It is important that teachers who wish to cooperate in this effort do so with the goal of increasing their own teaching effectiveness as well as that of future teachers.

It is our hope that cooperating departments will agree to teach these units during the period from November 1, 1981, to February 1, 1982. Each unit will require approximately six weeks of class time.

I am asking for your cooperation and assistance in field testing these materials and request that you discuss your interest in participating with your principal and return the enclosed response postcard at your earliest convenience. Further information concerning your responsiblity in that regard will be provided, if you are interested, by contacting me at (515) 294-5872 or a member of the Project 2000 staff at (515) 294-8454.

I thank you for your cooperation and will look forward to hearing from you.

Sincerely,

Alan A. Kahler
Professor, Agricultural Education
Director, Project 2000

AAK/mt

Enc. (postcard)

Iowa State University of Science and Technology Ames, Iowa 50011

Department of Agricultural Education
223 Curtiss Hall
Telephone 515-294-5872

September 21, 1981

I hope that your school year has gotten off to a smooth start and that you have set some high goals for your program for the year. We here at ISU are beginning to get settled after the transition from a quarter to the semester system. Many courses have undergone drastic revisions in the process, but students appear to be adjusting rather well.

The purpose of this letter is to identify vocational agriculture teachers who would be willing to participate in a study of vocational agriculture curriculums in the state of Iowa as a part of Project 2000. I am asking participating instructors to meet the following qualifications:

1. Teach units on Soybean Production, Soil Fertility and Fertilizers, and Agricultural Business Management during the period from November 1, 1981, to February 1, 1982 (approximately six weeks for each unit).

2. Administer pre-test and post-test instruments to students in the relevant classes.

Vocational agriculture departments who wish to cooperate in this effort will incur no additional expense in their programs. Pre-test and post-test instruments will be provided along with further instructions.

The results of your input will be useful in a determination of the need for development of instructional materials in these areas. I would ask that you discuss your interest in participating in this study with your principal and return the enclosed postcard at your earliest convenience.

I thank you in advance for your cooperation and look forward to hearing from you.

Sincerely,

Alan A. Kahler
Professor, Agricultural Education
Director, Project 2000

AAK/mt

Enc. (postcard)

P. S. If you have questions, please feel free to contact me at (515) 294-5872.

Teacher Response Postcard

____
(School)

I ____am ____am not interested in participating in Project 2000's curriculum study.

I plan to teach:

____ Soybean Production to ____ students.

____ Soil Fertility & Fertilizers to ____ students.

____ Agricultural Business Management to ____ students.

Principal

Vo Ag Teacher

Iowa State University of Science and Technology Ames, Iowa 50011

Department of Agricultural Education
223 Curtiss Hall
Telephone 515-294-5872

November 4, 1981

Dear Vo Ag Instructor,

Thank you for agreeing to participate in Project 2000's evaluation of curriculum materials. Enclosed you will find an assortment of materials which will help us evaluate the Agriculture/Agribusiness Management unit.

Please review the contents of this envelope which contains:

1. One instructional unit in Agriculture/Agribusiness Management
2. Informed Consent Forms (one for each student in Agriculture/ Agribusiness Management)
3. Agriculture/Agribusiness Management Knowledge Inventory (one for each student in Agriculture/Agribusiness Management)
4. General Purpose-NCS-Answer Sheets (one for each student in Agriculture/Agribusiness Management)
5. Agriculture/Agribusiness Management Attitude Inventory (one for each student in Agriculture/Agribusiness Management)
6. Guidelines for Collecting Student Information

If you find that you have not received any of the above items in the proper quantities, please contact us immediately at (515) 294-8454.

Before beginning instruction in this subject matter unit, it is important to review the materials needed throughout the unit and to order that information which is not currently on hand. We are asking that each instructor proceed through each problem area and utilize each learning activity provided. Learner needs are identified in several of the activities provided. These are areas which can be emphasized to improve the quality of education without diluting the subject matter being taught.

Prior to initiating the instructional phase of this evaluation, we would encourage you to ask your building principal or guidance counselor to administer the Agriculture/Agribusiness Knowledge Inventory and Agriculture/Agribusiness Attitude Inventory to students in the class. There are several reasons for this request. By utilizing these administrative personnel, the vocational agriculture program can publicize its attempt to provide the highest quality instruction to students in the district. Also, students may be encouraged to put forth a more honest effort if administrators participate in this fashion. The final decision regarding who administers these instruments will be left with you.

Both the Knowledge Inventory and Attitude Inventory must be completed and returned to us before beginning instruction in this unit. Please review each Knowledge Inventory Answer Sheet and Attitude Inventory to check that the students have provided their names as requested. Failure to supply names will unable us to match pre-test scores with post-test scores for evaluation purposes. It is important to stress that individual scores and the scores of students in your program will be combined with other students and programs, and no comparisons will be made between individual students or programs.

We are asking that all copies of the inventory forms and answer sheets be returned to our office immediately after completion, and we will respect your honesty and integrity not to duplicate these materials.

Informed Consent Forms should be distributed to students for their own and their parents' signatures. These forms, required of all projects of this nature, must be completed and returned to our office before we can utilize information provided by students in your program.

Approximately two weeks prior to concluding instruction in this unit, please contact our office so that we may send out materials needed for the post-test phase of the evaluation process.

The evaluation of instructional materials is of extreme importance. We sincerely appreciate your cooperation in this attempt and welcome any suggestions you may have which will improve the materials provided or the evaluation process.

Again, thank you for your cooperation.

Sincerely,

Alan A. Kahler
Professor, Agricultural Education
Director, Project 2000

AAK/mt
Enclosures

Iowa State University of Science and Technology Ames, Iowa 50011

Department of Agricultural Education
223 Curtiss Hall
Telephone 515-294-5872

November 4, 1981

Dear Vo Ag Instructor,

Thank you for agreeing to participate in the evaluation of instructional materials being conducted by Project 2000.

I am sure that each of you understand the importance of evaluating instructional materials before allowing their use on a state-wide basis. For that reason, the need for evaluating the quality of instructional materials becomes apparent.

Your vocational agriculture program was selected as a "control" school for this evaluation effort. Therefore, we are asking you to teach a unit on Soil Fertility and Fertilizers according to each of the problem areas outlined on a separate page in this package. The intent of using "control" groups is to determine the effectiveness of materials developed by Project 2000 relative to materials which are currently being used.

Enclosed are multiple copies of forms to collect information from students. You should have an adequate number of the following items:

1. Soil Fertility and Fertilizers Problem Areas and Study Questions (one copy)
2. Informed Consent Forms (one per student in class)
3. Soil Fertility and Fertilizers Knowledge Inventory (one per student in class)
4. General Purpose-NCS-Answer Sheets (one per student in class)
5. Soil Fertility and Fertilizers Attitude Inventory (one per student in class)
6. Guidelines for Collecting Student Information

If you find that you have not received any of the above items in the proper quantities, please contact us immediately at (515) 294-8454.

We would encourage you to ask your building principal or guidance counselor to administer the Soil Fertility and Fertilizers Knowledge Inventory and Attitude Inventory. The purpose for this request is two-fold: First, by utilizing these administrative personnel, the vocational agriculture program can publicize its attempt to provide the highest quality instruction to students in the district through participation in this evaluation. Second, students may be encouraged to put forth a more honest effort if administrators participate in this fashion. The final decision regarding who administers these instruments will be left with you.

Both the Knowledge Inventory and Attitude Inventory must be completed and returned to us before beginning instruction in this unit. Please review each Knowledge Inventory Answer Sheet and Attitude Inventory to check that students have provided their names as requested. Failure to supply names will unable us to match pre-test with post-test scores for evaluation purposes. It is important to stress that individual scores and the scores of students in your program will be combined with other students and programs, and no comparisons will be made between individual students or programs.

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The evaluation of instructional materials is of extreme importance. We sincerely appreciate your cooperation in this attempt and welcome any suggestions you may have which will improve this evaluation process.

Sincerely,

Alan A. Kahler
Professor, Agricultural Education
Director, Project 2000

AAK/mt
Enclosures

SOIL FERTILITY AND FERTILIZERS

Problem Areas and Study Questions

I. What is the Role of Essential Nutrients to Plant Growth?

Study Questions:

1. What are essential elements for plant growth?
2. Where do the essential plant nutrients come from?
3. What is the role of primary nutrients in plant growth?
4. What is the role of secondary nutrients in plant growth?
5. What is the role of micro-nutrients in plant growth?
6. How are nutrient deficiencies identified?

II. What are Some Concepts of Soil Fertility and Productivity?

Study Questions:

1. What is the role of soil colloids and ions?
2. What is cation exchange capacity?
3. What is the role of organic matter in soil?
4. How are nutrients absorbed by plants
5. What factors affect soil productivity?
6. How do fertilizer salts react in the soil?

III. Why Should Acid Soils be Limed?

Study Questions:

1. What is soil pH?
2. What factors affect soil pH?
3. How do I determine lime needs?
4. What liming materials are available in the market?
5. How often and how much lime should one apply to acid soil?
6. What are the different methods of applying lime to the soil?

IV. How are the Nutrient Needs Determined?

Study Questions:

1. How do I determine crop yield goals for each field on the farm?
2. Where could I get a soil survey report for my farm?
3. What are the procedures for obtaining a representative soil sample?
4. What information do I send with my soil samples?
5. What kinds of soil tests are required?
6. What are the costs for different soil tests?
7. Where do I send my soil samples?

V. How do I Interpret the Soil Test Reports?

Study Questions:

1. What information is found on a soil test report?
2. What do the numbers on the report mean?
3. How do I adjust the recommendations to my farm situation?
4. What kinds of soil tests are reported?

VI. What are the Different Sources of Nutrients?

Study Questions:

1. How are the nutrients lost in the soil?
2. What kinds of nutrients are available in the animal manure produced on the farm?
3. How important are green manure crops?
4. What are the important sources from commercial fertilizers of nitrogen, phosphorus, and potassium?
5. What are the sources of micro-nutrients?

VII. How Should Fertilizers be Selected?

Study Questions:

1. What factors should I consider in selecting the proper analysis or grade and amount of fertilizer?
2. What information is found on a fertilizer bag?
3. How should the analysis or grade information be interpreted and used?
4. What does fertilizer ratio mean and how is it used?
5. What are different forms of fertilizers?
6. How do I compare costs of fertilizer materials?

VIII. How Should Fertilizers be Applied?

Study Questions:

1. What are the factors which affect the application of fertilizers?
2. What are the different methods of applying fertilizers?
3. What is the best time to apply fertilizer?
4. How much fertilizer can I safely apply?
5. What types of equipment are used to apply fertilizer?

IX. How Should Fertilizer Materials be Handled Safely?

Study Questions:

1. What are some safety precautions in handling and storing fertilizers?
2. What are some safety hazards when using fertilizers?
3. How do I administer first-aid treatment to victims of fertilizer accidents?

GUIDELINES FOR COLLECTING STUDENT INFORMATION

Purpose of Evaluation:

The purpose of this project is to collect information necessary to evaluate instructional materials in Vocational Agriculture which were developed by Iowa State University.

Directions:

1. Have principal or guidance counselor administer the Knowledge Inventory to students. Make sure each student uses a No. 2 (soft-lead) pencil to record answers on the answer sheet provided.

2. Administer the Attitude Inventory to students. The instructions should be self-explanatory. Please emphasize to them that they should respond to each and every item.

3. Distribute Informed Consent Forms to students and explain that it is essential these forms be completed and returned.

4. Mail all four items for each student (i.e. Knowledge Inventory, Answer Sheet, Attitude Inventory, and Informed Consent Form) to:

Dr. Alan A. Kahler
Department of Agricultural Education
219 Curtiss Hall
Iowa State University
Ames, Iowa 50011

Thanks again for your help and cooperation. If you have questions, please call (515) 294-8454.

Iowa State University of Science and Technology Ames, Iowa 50011

Department of Agricultural Education
223 Curtiss Hall
Telephone 515-294-5872

Dear

Enclosed you will find the materials needed to complete the data collection process involved with the evaluation of curriculum materials developed through Project 2000. Please have your students complete the Knowledge Inventories and the Attitude Inventories as they did for the pre-test. We would also ask that you complete the Informed Consent Form and the Teacher Data Instrument which are also enclosed. After completing all of the enclosed materials, we would ask that you return them to us as quickly as possible. Feel free to keep the Knowledge Inventory (tests) if you so desire.

We hope that you have enjoyed participating in this evaluation and it has not created an undue hardship on your teaching load. Results should be available in time to be presented at the Vo-Ag Teachers Conference in Des Moines next summer.

Again, thank you for your help in making this evaluation possible and we look forward to receiving the materials from you.

Sincerely,

Alan A. Kahler

encl.

APPENDIX B: INFORMED CONSENT FORMS

Iowa State University of Science and Technology Ames, Iowa 50011

Department of Agricultural Education
223 Curtiss Hall
Telephone 515-294-5872

INFORMED CONSENT FORM

Informed Consent of Student

I voluntarily agree to participate in the activities associated with the study of Agriculture/Agribusiness Management in my vocational agriculture class. I further understand that the information which I provide will be held in strict confidence and that my responses will be combined with other responses and used only in the interest of improving instruction in vocational agriculture. The information that I provide through my participation in these activities will be used, along with that provided by other students, as a basis for developing instructional materials on agricultural subjects that will be shared with all vocational agriculture programs in the state of Iowa.

______________________ (Date)

______________________ (Print Name of Student)

______________________ (Signature of Student)

______________________ (Box Number or Route Number)

______________________ (Town) (State) (Zip)

______________________ (Name of School)

Informed Consent of Parent/Guardian

My son/daughter, ______________________, has my permission to participate in the activities described above.

______________________ (Date)

______________________ (Print Name of Parent)

______________________ (Signature of Parent)

Vocational Agriculture Instructors:

Please read and sign the following INFORMED CONSENT STATEMENT which indicates your willingness to provide information necessary to complete the evaluation of curriculum materials developed and tested as a part of Project 2000.

INFORMED CONSENT STATEMENT

I voluntarily agree to provide the information as requested below as a part of my involvement with Project 2000's evaluation of curriculum materials. I understand that the information which I provide will be held in confidence and that my responses will be combined with other responses and used only in the interest of improving instruction in vocational agriculture.

____________________ (Date)

______________________________ (Signature)

APPENDIX C: DATA COLLECTION INSTRUMENTS

SOIL FERTILITY AND FERTILIZERS KNOWLEDGE INVENTORY

(POST-TEST)

Directions:

The purpose of this test is to determine your present level of knowledge of Soil Fertility and Fertilizers. Using a soft lead (No.2) pencil, please enter your name in the space provided on the upper left portion of the answer sheet. Above your name, please write the letters "SF" in the blank area.

Read each question and response carefully. After deciding on the correct or best response, darken the cirle on the answer sheet corresponding to your choice. Please answer all questions.

After completing this test, please return both the answer sheet and test to your instructor.

1. What is the chemical symbol for Potassium?

   A. N
   B. P
   C. K
   D. PO

2. Nitrification is the process by which:

   A. Nitrogen changes to available forms.
   B. Nitrogen is applied to the soil.
   C. Nitrogen is washed away.
   D. Nitrogen changes to unavailable forms.

3. A soil with a pH value of 5.2 may be made less acid by applying:

   A. Nitrogen.
   B. Potassium.
   C. Phosphorus.
   D. Lime.

4. Soil testing makes it possible to:

   A. determine nutrient level in the plants.
   B. determine management level of the farmer.
   C. suggest amounts of fertilizer applied.
   D. determine crop yield.

5. For a 5-20-10 fertilizer grade, what percent is potash?

   A. 20
   B. 10
   C. 5
   D. 35

NOTE: TURN TO THE BACK SIDE OF THIS PAGE FOR ITEM NUMBER 6.

6. What is cation exchange capacity (CEC)?

   A. Total number cations a soil can hold.
   B. Total number of exchangeable cations a soil can hold.
   C. Refers to the number of ions in soil particles.
   D. All of the above.

7. Nutrients are lost in the soil through:

   A. changing from available to unavailable form.
   B. leaching.
   C. erosion.
   D. All of the above.

8. Farmer Jim Alizer divided his field into 8 sampling areas of 10 acres each. How much money will Jim have to pay if he wants to have all possible tests performed on all of the samples? Cost of soil test is $8 per sample. Use the following formula:

   Total cost = No. of sampling areas x $8 per sample

   A. $72
   B. $64
   C. $56
   D. $50

9. Assume Farmer Jones paid $35 for all tests on his 70 acre farm. What is the cost per acre for soil testing? Use the formula:

$$\text{Cost per acre} = \frac{\text{Total Cost}}{\text{Total Acre}}$$

   A. $2/acre
   B. $1.50/acre
   C. $1/acre
   D. $.50/acre

10. What is the best first-aid treatment for ammonia burns?

    A. Wash with water.
    B. Rush immediately to hospital.
    C. Take aspirin.
    D. Lie flat on back.

11. Soil A has a pH reading of 6 and Soil B has a pH reading of 4. Which of the following statements is true?

    A. Soil A is more acid than Soil B.
    B. Soil B is more acid than Soil A.
    C. Soil B is more basic than Soil A.
    D. Both Soil A and B are basic soil.

12. When selecting soil sampling areas, each sample should represent:

    A. a uniform soil area with similar past management.
    B. a uniform soil area.
    C. one entire field.
    D. a combination of odd areas or areas without similar past treatment.

13. Which of the following factors affect fertilizer application?

    A. Time of application.
    B. Crop and stage of growth.
    C. Equipment available.
    D. All of the above.

14. When taking a soil sample, the best results are obtained when your sampling areas are:

    A. no less than 50 acres.
    B. between 20 to 50 acres.
    C. no more than 5 to 10 acres.
    D. less than 1 acre.

15. Which of the following factors should be considered when selecting a fertilizer?

    A. Soil test
    B. Yield goal
    C. Cost
    D. All of the above

16. When is the best time to apply fertilizers?

    A. Just prior to harvesting the crop.
    B. Just prior to pollination.
    C. Depends on the soil, climate, crop and nutrient applied.
    D. Immediately after planting the crop.

17. Generally, soil should be tested:

    A. every 3-5 years.
    B. every 20 years.
    C. every 10 years.
    D. each year.

18. Why should a small squirt bottle of water be carried by persons handling anhydrous ammonia?

    A. To check for leaks in hoses.
    B. To help swallow aspirin after inhaling fumes.
    C. To cool the applicator if it becomes over-heated.
    D. To flush eyes if they come in contact with fumes.

NOTE: TURN TO THE BACK SIDE OF THIS PAGE FOR ITEM NUMBER 19.

Use the soil test report below to answer questions 19, 20 and 21:

NUTRIENT RECOMMENDATION - Pound/Acre

Sample No.	Soybeans			Corn or Sorghum Grain			Corn or Sorghum Silage		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1	40	30	10	150	45	0	150	65	20
2	40	20	0	170	50	0	170	65	0

19. What is the recommendation for potassium when corn silage is to be grown in sampling area No. 2?

    A. 20
    B. 10
    C. None
    D. 65

20. What is the recommendation for nitrogen when corn grain is to be grown in sampling area No. 1?

    A. 150
    B. 40
    C. 170
    D. 45

21. What is the recommendation for phosphate when soybeans are to be grown in sampling area No. 2?

    A. 65
    B. 50
    C. 20
    D. 30

22. Which set of the following elements contains the primary nutrients?

    A. Nitrogen, phosphorus, potassium.
    B. Nitrogen, calcium, potassium.
    C. Calcium, phosphorus, iron.
    D. Sulfur, iron, boron.

23. Which of the following factors affect the availability of nutrients?

    A. Soil water content.
    B. Soil pH and texture.
    C. Both A and B are correct.
    D. Soil type and soil color.

24. Soil pH is a measure of:

    A. soil pressure.
    B. the degree of soil acidity.
    C. the amount of nitrogen in the soil.
    D. the percent hydrogen in the soil.

25. How can fertilizers be applied?

    A. Broadcast application or band application.
    B. Soil injection.
    C. None of the above.
    D. Both A and B are correct.

26. Which of the following is <u>not</u> a nitrogen fertilizer?

    A. Anhydrous ammonia
    B. Concentrated superphosphate
    C. Urea
    D. Ammonium nitrate

27. Soils with pH level less than 7 are considered to be:

    A. basic soils.
    B. acid soils.
    C. neutral.
    D. None of the above.

28. If anhydrous ammonia (82-0-0) is sold at $164/ton, what is the cost per pound of nitrogen?

$$\text{Cost per pound} = \frac{\text{Price per ton}}{\text{\% nutrient x 2000}}$$

    A. $.20 per pound
    B. $.10 per pound
    C. $.30 per pound
    D. $.40 per pound

29. If a plant is light green in color with yellow leaves, it may be short in:

    A. nitrogen.
    B. iron.
    C. phosphorus.
    D. zinc.

30. The amount of liming material to be applied to the soil depends on:

    A. the type crop to be grown.
    B. the pH of the soil.
    C. the neutralizing value of the liming material.
    D. All of the above.

NOTE: TURN TO THE BACK SIDE OF THIS PAGE FOR ITEM NUMBER 31.

31. Ammonium nitrate is a common source of:

    A. phosphate.
    B. nitrogen.
    C. iron.
    D. potassium.

32. Which one of the following is <u>not</u> normally found on a fertilizer bag?

    A. Pounds per bag.
    B. Name or brand of fertilizer.
    C. Guaranteed chemical compostion.
    D. Fertilizer pH.

33. The chemical symbol for nitrogen is:

    A. NO_3^-
    B. N
    C. MO
    D. NO

34. Which of the following is a common potassium fertilizer?

    A. Borase
    B. Anhydrous ammonia
    C. Iron sulfate
    D. Murate of potash

35. In a 100 pound bag of blended fertilizer with a grade analysis of 5-20-10 (on N - P_2O_5 - K_2O basis), how many pounds of nitrogen are in the bag?

    A. 5
    B. 10
    C. 20
    D. 35

36. Nutrients are supplied for crop use:

    A. from animal manures.
    B. from commercial fertilizers.
    C. from herbicides.
    D. Both A and B are correct.

37. What is the fertilizer ratio for a 5-20-20 grade?

    A. 1-2-2
    B. 4-4-4
    C. 1-4-4
    D. 2-2-2

38. When transferring ammonia from a nurse tank to an applicator, one should:

    A. wear a face shield and rubber gloves.
    B. have at least 5 gallons of water available.
    C. know how to operate equipment properly.
    D. All of the above.

39. Which of the following fertilizers poses the greatest health hazard?

    A. Urea
    B. Superphosphate
    C. Potash
    D. Anhydrous ammonia

40. Which one of the following is a liming material?

    A. Anhydrous ammonia
    B. Superphosphate
    C. Calcium carbonate
    D. Urea

School No. _____ Name ________________________

Student No. _____

SOIL FERTILITY AND FERTILIZERS ATTITUDE INVENTORY

Directions: Please evaluate each of the following concepts listed in BOLD PRINT placing an "X" on each line in relation to your feelings toward the concept presented. BE HONEST! Please place only one mark on each and every row provided.

Example: I FEEL THAT PARTICIPATION IN FFA ACTIVITIES IS:

If you felt participation in FFA activities was important, you might mark the following:

UNIMPORTANT:____:____:____:____:____:_X_:____:IMPORTANT

If you felt participation in FFA activities was totally meaningless, you would mark the following:

MEANINGLESS:_X_:____:____:____:____:____:____:MEANINGFUL

I FEEL THAT TESTING SOILS IS:

1. MEANINGLESS:____:____:____:____:____:____:____:MEANINGFUL
2. UNIMPORTANT:____:____:____:____:____:____:____:IMPORTANT
3. WORTHLESS:____:____:____:____:____:____:____:VALUABLE
4. FOOLISH:____:____:____:____:____:____:____:WISE
5. UNNECESSARY:____:____:____:____:____:____:____:NECESSARY

I FEEL THAT MAKING DECISIONS ABOUT FERTILIZERS IS:

6. UNIMPORTANT:____:____:____:____:____:____:____:IMPORTANT
7. SIMPLE:____:____:____:____:____:____:____:COMPLEX
8. UNNECESSARY:____:____:____:____:____:____:____:NECESSARY
9. EASY:____:____:____:____:____:____:____:DIFFICULT
10. FOOLISH:____:____:____:____:____:____:____:WISE

NOTE: TURN TO THE BACK SIDE OF THIS PAGE TO CONTINUE

I FEEL SAFE USE OF FERTILIZER MATERIALS IS:

11. EASY:_____:_____:_____:_____:_____:_____:_____:DIFFICULT

12. FOOLISH:_____:_____:_____:_____:_____:_____:_____:WISE

13. UNNECESSARY:_____:_____:_____:_____:_____:_____:_____:NECESSARY

14. UNIMPORTANT:_____:_____:_____:_____:_____:_____:_____:IMPORTANT

15. BAD:_____:_____:_____:_____:_____:_____:_____:GOOD

I FEEL LEARNING ABOUT SOIL FERTILITY AND FERTILIZERS IS:

16. UNIMPORTANT:_____:_____:_____:_____:_____:_____:_____:IMPORTANT

17. EASY:_____:_____:_____:_____:_____:_____:_____:DIFFICULT

18. BORING:_____:_____:_____:_____:_____:_____:_____:INTERESTING

19. WORTHLESS:_____:_____:_____:_____:_____:_____:_____:VALUABLE

20. USELESS:_____:_____:_____:_____:_____:_____:_____:USEFUL

I FEEL APPLYING AGRICULTURAL KNOWLEDGE TO SPECIFIC SITUATIONS IS:

21. SIMPLE:_____:_____:_____:_____:_____:_____:_____:COMPLEX

22. WORTHLESS:_____:_____:_____:_____:_____:_____:_____:VALUABLE

23. EASY:_____:_____:_____:_____:_____:_____:_____:DIFFICULT

24. BORING:_____:_____:_____:_____:_____:_____:_____:INTERESTING

25. UNIMPORTANT:_____:_____:_____:_____:_____:_____:_____:IMPORTANT

I FEEL BEING FAMILIAR WITH SOURCES OF INFORMATION IS:

26. WORTHLESS:_____:_____:_____:_____:_____:_____:_____:VALUABLE

27. UNIMPORTANT:_____:_____:_____:_____:_____:_____:_____:IMPORTANT

28. USELESS:_____:_____:_____:_____:_____:_____:_____:USEFUL

29. EASY:_____:_____:_____:_____:_____:_____:_____:DIFFICULT

30. UNNECESSARY:_____:_____:_____:_____:_____:_____:_____:NECESSARY

Note: Have you made an "X" on each row for each concept and written your name on the front? THANK YOU!

STUDENT DATA INSTRUMENT

Directions: Please respond to each of the following items in the blank provided before each question. Round your answers to the nearest whole number if necessary.

_____ 1. How many years have you been an FFA member? (0, 1, 2, 3, 4)

_____ 2. How many semesters of Vo-Ag classes have you completed?

_____ 3. How many semesters of Economics or Business classes have you completed?

_____ 4. How many semesters of Science classes have you completed?

_____ 5. How many semesters of Mathematics classes have you completed?

_____ 6. Where do you live?

1. In a town or city
2. In a rural area, not on a farm
3. On a farm

_____ 7. How many total acres does your family farm? (Both own or rent)

_____ 8. What is your grade classification in school?

1. Freshman (9th)
2. Sophomore (10th)
3. Junior (11th)
4. Senior (12th)

_____ 9. What grades do you normally receive in your high school courses?

1. Mostly A's
2. Mostly B's
3. Mostly C's
4. Mostly D's

____ 10. What do you plan to do after high school graduation?

1. Go to college
2. Farm
3. Work in agribusiness
4. Work but not in an agribusiness
5. Enter the military
6. Undecided
7. Other (specify) ______________________

TEACHER DATA INSTRUMENT

Directions: Please respond to each of the following items as each relates to you or your teaching situation.

_____ 1. How many years have you taught vocational agriculture? (Including this year)

_____ 2. How many students are enrolled in your high school? (9-12)

_____ 3. How many students are enrolled in your Vo-Ag Department?

_____ 4. How many day-classes do you teach per day?

_____ 5. How many vo-ag day-classes do you teach per day?

_____ 6. Write the number which indicates the highest level of your education.

9, 10, 11, 12	13, 14, 15, 16	17, 18, 19, 20
(High School)	(College)	(Graduate)

_____ 7. Did you take a college course that focused on soil fertility and fertilizers?

1. Yes
2. No

_____ 8. How many class periods did you devote to teaching this unit?

_____ 9. How would you rate your general knowledge of soil fertility and fertilizers?

1	2	3	4	5
None	Fair	Average	Good	Excellent

_____ 10. Have you had any experience in a fertilizer related business?

1. Yes
2. No

_____ 11. If you answered "Yes" to question 10, what was the length of experience? (Number of months)

_____ 12. Who administered the pre-test?

1. Myself
2. Principal
3. Guidance Counselor
4. Other

_____ 13. Who administered the post-test?

1. Myself
2. Principal
3. Guidance Counselor
4. Other

INSTRUCTOR EVALUATION OF SOIL FERTILITY AND FERTILIZERS INSTRUCTIONAL UNIT

Directions: Please evaluate the above instructional unit developed by Project 2000 using the following scale. Place an "X" on each line below in relation to your feelings about the unit in general.

1. ineffective:____:____:____:____:____:____:____:effective
2. useless:____:____:____:____:____:____:____:useful
3. inappropriate:____:____:____:____:____:____:____:appropriate
4. technically inaccurate:____:____:____:____:____:____:____:technically accurate
5. complex:____:____:____:____:____:____:____:simple
6. difficult to read:____:____:____:____:____:____:____:easy to read
7. technically out-of-date:____:____:____:____:____:____:____:technically up-to-date
8. visually unappealing:____:____:____:____:____:____:____:visually appealing
9. not needed:____:____:____:____:____:____:____:needed
10. worthless:____:____:____:____:____:____:____:worthwhile
11. incomplete:____:____:____:____:____:____:____:complete

Using the following scale, rate each of the statements below as they pertain to the instructional unit identified above. Enter your response on the blank provided before each of the statements.

No value		Little value		Some value		Much value		Utmost value
1	2	3	4	5	6	7	8	9

What is/was the value of:

____ 12. Problem area questions in identifying important components to be studied in the subject matter area?

____ 13. Study questions in focusing the direction of the problem area?

____ 14. Learner needs statements in identifying opportunities to emphasize learning beyond the subject matter level?

____ 15. Interest approach activities in stimulating student interest in the problem area?

____ 16. Learning activities in providing realistic experiences for students to acquire knowledge and understanding in each problem area?

____ 17. Conclusions in providing accurate responses to the problem statement?

____ 18. Evaluation criteria in identifying important components of student achievement to be assessed?

____ 19. Optional learning activities in providing additional strategies for teaching in each problem area?

____ 20. Problem area outlines in decreasing the preparation time required to teach the unit?

____ 21. Developing instructional units in other subject matter areas for future use?

____ 22. Distributing this instructional unit for use by vocational agriculture instructors throughout Iowa?

____ 23. Additional comments or suggestions for changing future units.

____

____

____

APPENDIX D: ITEM AND FACTOR ANALYTIC RESULTS

Table D.1. Item analysis of the knowledge inventory instrument (pretest form)

ITEM	NA	NR	%R	VAR	STDEV	COV	COR	ITEM
1	310	252	81	0.15	0.39	0.92	0.34	1
2	310	169	55	0.25	0.50	1.24	0.36	2
3	310	189	61	0.24	0.49	1.59	0.47	3
4	307	77	25	0.19	0.43	0.37	0.12	4
5	309	247	80	0.16	0.40	1.15	0.41	5
6	310	257	83	0.14	0.38	0.87	0.33	6
7	310	151	49	0.25	0.50	1.53	0.44	7
8	308	161	52	0.25	0.50	1.24	0.36	8
9	310	152	49	0.25	0.50	1.05	0.30	9
10	309	72	23	0.18	0.42	0.36	0.12	10
11	310	243	78	0.17	0.41	1.32	0.46	11
12	310	180	58	0.24	0.49	1.40	0.41	12
13	310	87	28	0.20	0.45	0.73	0.23	13
14	310	236	76	0.18	0.43	1.66	0.56	14
15	310	103	33	0.22	0.47	0.56	0.17	15
16	309	159	51	0.25	0.50	1.36	0.39	16
17	309	245	79	0.16	0.41	1.68	0.59	17
18	310	157	51	0.25	0.50	1.57	0.45	18
19	309	247	80	0.16	0.40	1.73	0.62	19
20	310	239	77	0.18	0.42	1.58	0.54	20
21	310	199	64	0.23	0.48	1.19	0.36	21
22	310	271	87	0.11	0.33	1.18	0.51	22
23	308	115	37	0.23	0.48	0.38	0.11	23
24	309	237	77	0.18	0.42	1.30	0.44	24
25	308	129	42	0.24	0.49	1.22	0.36	25
26	310	248	80	0.16	0.40	1.31	0.47	26
27	309	164	53	0.25	0.50	1.06	0.30	27
28	309	243	79	0.17	0.41	1.24	0.43	28
29	309	235	76	0.18	0.43	1.62	0.54	29
30	310	146	47	0.25	0.50	1.26	0.36	30
31	310	180	58	0.24	0.49	1.97	0.57	31
32	310	225	73	0.20	0.45	1.33	0.43	32
33	310	206	66	0.22	0.47	1.65	0.50	33
34	308	207	67	0.22	0.47	1.29	0.39	34
35	310	123	40	0.24	0.49	1.09	0.32	35
36	310	152	49	0.25	0.50	1.26	0.36	36
37	309	192	62	0.24	0.49	1.51	0.45	37
38	309	185	60	0.24	0.49	1.36	0.40	38
39	308	164	53	0.25	0.50	0.97	0.28	39
40	307	138	45	0.25	0.50	0.96	0.28	40

NA=NUMBER ATTEMPTING THE ITEM
OM=NUMBER OMITTING THE ITEM
NR=NUMBER ANSWERING CORRECTLY
%R=PERCENT ANSWERING CORRECTLY
VAR=ITEM VARIANCE
STDEV=ITEM STANDARD DEVIATION
COV=ITEM-SCORE COVARIANCE
COR=ITEM-SCORE CORRELATION

Table D.2. Item analysis of the knowledge inventory instrument (posttest form)

ITEM	NA	NR	%R	VAR	STDEV	COV	COR	ITEM
1	273	223	82	0.15	0.39	1.46	0.46	1
2	273	154	56	0.25	0.50	1.67	0.41	2
3	272	220	81	0.15	0.39	1.59	0.50	3
4	273	215	79	0.17	0.41	1.21	0.37	4
5	273	192	70	0.21	0.46	1.70	0.46	5
6	273	73	27	0.20	0.44	0.60	0.17	6
7	272	212	78	0.17	0.41	1.61	0.48	7
8	272	228	84	0.14	0.37	1.93	0.64	8
9	272	152	56	0.25	0.50	1.80	0.45	9
10	273	247	90	0.09	0.29	1.36	0.57	10
11	273	149	55	0.25	0.50	1.69	0.42	11
12	273	118	43	0.25	0.50	1.59	0.39	12
13	273	231	85	0.13	0.36	1.78	0.61	13
14	272	192	71	0.21	0.46	1.81	0.49	14
15	271	240	89	0.10	0.32	1.51	0.58	15
16	272	222	82	0.15	0.39	1.61	0.51	16
17	273	194	71	0.21	0.45	1.46	0.39	17
18	273	248	91	0.08	0.29	1.31	0.56	18
19	272	199	73	0.20	0.44	1.83	0.51	19
20	273	239	88	0.11	0.33	1.69	0.63	20
21	273	232	85	0.13	0.36	1.72	0.59	21
22	273	223	82	0.15	0.39	2.12	0.67	22
23	273	209	77	0.18	0.42	1.80	0.52	23
24	273	191	70	0.21	0.46	1.70	0.46	24
25	272	229	84	0.13	0.36	1.86	0.63	25
26	273	214	78	0.17	0.41	1.62	0.48	26
27	273	163	60	0.24	0.49	1.86	0.47	27
28	273	164	60	0.24	0.49	1.65	0.41	28
29	272	173	64	0.23	0.48	1.40	0.36	29
30	273	192	70	0.21	0.46	1.67	0.45	30
31	273	219	80	0.16	0.40	1.99	0.61	31
32	273	146	53	0.25	0.50	1.33	0.33	32
33	273	247	90	0.09	0.29	1.62	0.68	33
34	273	197	72	0.20	0.45	1.92	0.53	34
35	273	179	66	0.23	0.48	1.98	0.51	35
36	272	209	77	0.18	0.42	2.13	0.62	36
37	272	231	85	0.13	0.36	1.64	0.56	37
38	273	243	89	0.10	0.31	1.53	0.60	38
39	273	234	86	0.12	0.35	1.70	0.60	39
40	273	190	70	0.21	0.46	1.81	0.48	40

NA=NUMBER ATTEMPTING THE ITEM
OM=NUMBER OMITTING THE ITEM
NR=NUMBER ANSWERING CORRECTLY
%R=PERCENT ANSWERING CORRECTLY
VAR=ITEM VARIANCE
STDEV=ITEM STANDARD DEVIATION
COV=ITEM-SCORE COVARIANCE
COR=ITEM-SCORE CORRELATION

Table D.3. Soil fertility and fertilizers attitude scale

Item number	Pretest		Posttest	
	Mean	Standard deviation	Mean	Standard deviation
1	5.83	1.15	6.00	1.14
2	5.98	1.19	6.09	1.19
3	6.00	1.27	6.09	1.19
4	5.97	1.20	6.15	1.08
5	5.78	1.38	5.95	1.18
6	6.11	1.35	6.18	1.12
7	2.62	1.51	2.68	1.50
8	5.98	1.37	6.13	1.05
9	2.87	1.57	3.05	1.55
10	5.98	1.38	6.15	1.09
11	4.04	1.88	4.13	1.89
12	6.37	1.16	6.37	1.02
13	6.26	1.22	6.27	1.07
14	6.36	1.11	6.36	1.08
15	6.34	1.12	6.34	1.01
16	5.69	1.45	6.02	1.15
17	3.19	1.55	3.28	1.67
18	4.39	1.85	4.62	1.88
19	5.69	1.32	6.00	1.17
20	5.78	1.38	6.09	1.17
21	3.23	1.62	3.28	1.75
22	5.82	1.26	5.93	1.23
23	3.39	1.68	3.37	1.74
24	4.97	1.64	5.28	1.58
25	5.79	1.36	6.01	1.21
26	5.96	1.33	5.99	1.30
27	5.95	1.34	6.09	1.24
28	5.91	1.36	6.12	1.18
29	3.67	1.78	3.63	1.82
30	5.70	1.41	6.02	1.28

Table D.4. Reliability analysis of the attitude scales (pretest form)

	SCALE MEAN IF ITEM DELETED	SCALE VARIANCE IF ITEM DELETED	CORRECTED ITEM-TOTAL CORRELATION	SQUARED MULTIPLE CORRELATION	ALPHA IF ITEM DELETED
AT1	24.10000	15.32654	0.73150	0.57952	0.88275
AT2	23.95806	14.44160	0.83486	0.71358	0.86078
AT3	23.94194	14.11959	0.81399	0.67439	0.86408
AT4	23.98387	15.16155	0.71784	0.52046	0.88525
AT5	24.18387	14.17644	0.68405	0.49050	0.89697
AT6	22.67419	19.60548	0.68564	0.62359	0.81346
AT7	23.50323	17.96601	0.66586	0.61116	0.81790
AT8	22.80968	19.24198	0.70148	0.65623	0.80886
AT9	23.79032	18.69699	0.56754	0.56697	0.84776
AT10	22.82258	19.13671	0.71233	0.67199	0.80613
AT11	25.59355	12.55918	0.09943	0.02737	0.90559
AT12	23.11290	11.45323	0.67786	0.61894	0.59780
AT13	23.20968	10.98826	0.69879	0.63776	0.58256
AT14	23.10645	11.70708	0.71106	0.71732	0.59617
AT15	23.11935	12.17665	0.60458	0.59896	0.62934
AT16	20.82258	15.79690	0.65836	0.54385	0.59421
AT17	21.83226	21.48633	0.05316	0.00508	0.82438
AT18	22.12903	14.39106	0.49952	0.28427	0.66244
AT19	20.84194	16.63837	0.65518	0.60039	0.60595
AT20	20.74839	15.98827	0.67948	0.64697	0.59059
AT21	21.28065	15.11516	0.42725	0.53449	0.60719
AT22	20.17742	16.79366	0.50966	0.46669	0.58377
AT23	21.48065	15.62907	0.35130	0.52067	0.64741
AT24	21.03226	15.85656	0.36094	0.35928	0.63995
AT25	20.17097	16.28459	0.49297	0.49178	0.58327
AT26	22.13871	15.35610	0.68323	0.64241	0.66225
AT27	22.14839	14.72872	0.75890	0.70222	0.63518
AT28	22.16774	14.77436	0.72784	0.67132	0.64382
AT29	23.86452	19.61265	0.04785	0.02079	0.91034
AT30	22.37742	14.69528	0.69207	0.56619	0.65309

Table D.5. Reliability analysis of the attitude scales (posttest form)

	SCALE MEAN IF ITEM DELETED	SCALE VARIANCE IF ITEM DELETED	CORRECTED ITEM-TOTAL CORRELATION	SQUARED MULTIPLE CORRELATION	ALPHA IF ITEM DELETED
PAT1	24.29677	16.28704	0.81888	0.68643	0.89896
PAT2	24.22581	15.65758	0.84150	0.72440	0.89410
PAT3	24.20323	15.84530	0.83277	0.70157	0.89593
PAT4	24.15806	16.96846	0.78434	0.62373	0.90614
PAT5	24.36774	16.85462	0.70770	0.50128	0.92105
PAT6	22.67097	13.38006	0.40788	0.53773	0.64276
PAT7	23.51290	11.48689	0.41648	0.33573	0.64440
PAT8	22.71613	12.63113	0.56990	0.55389	0.58578
PAT9	23.88710	11.93220	0.33333	0.32388	0.69123
PAT10	22.70968	12.54327	0.54281	0.49622	0.59202
PAT11	25.43548	12.95861	-0.04534	0.00985	0.89802
PAT12	22.91290	10.81116	0.61184	0.67802	0.50230
PAT13	23.01290	10.14223	0.69123	0.73999	0.45953
PAT14	22.91613	10.21301	0.66737	0.65851	0.46874
PAT15	22.94839	11.21416	0.54730	0.45580	0.53034
PAT16	21.42581	14.68542	0.65343	0.63758	0.49542
PAT17	22.72258	19.40499	-0.03007	0.00470	0.80124
PAT18	22.85161	12.64458	0.40345	0.23330	0.60512
PAT19	21.43548	14.74502	0.63276	0.56842	0.50206
PAT20	21.35806	14.37947	0.66201	0.66933	0.48618
PAT21	21.84194	16.07526	0.39352	0.59169	0.61018
PAT22	20.58710	18.39207	0.46445	0.62476	0.58438
PAT23	21.94839	15.92613	0.40565	0.58899	0.60362
PAT24	21.33871	17.62277	0.31455	0.31658	0.64628
PAT25	20.51613	17.93340	0.53139	0.66007	0.56082
PAT26	22.63548	13.69518	0.76760	0.80008	0.58635
PAT27	22.55484	14.86915	0.67073	0.70803	0.63011
PAT28	22.52903	14.69657	0.74022	0.71063	0.61011
PAT29	24.29355	19.13362	0.01484	0.01161	0.91134
PAT30	22.64516	14.81867	0.64240	0.55083	0.63750